The INSTITUTE Spokesman

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OFFICIAL PUBLICATION

NATIONAL LUBRICATING GREASE INST

NLGI

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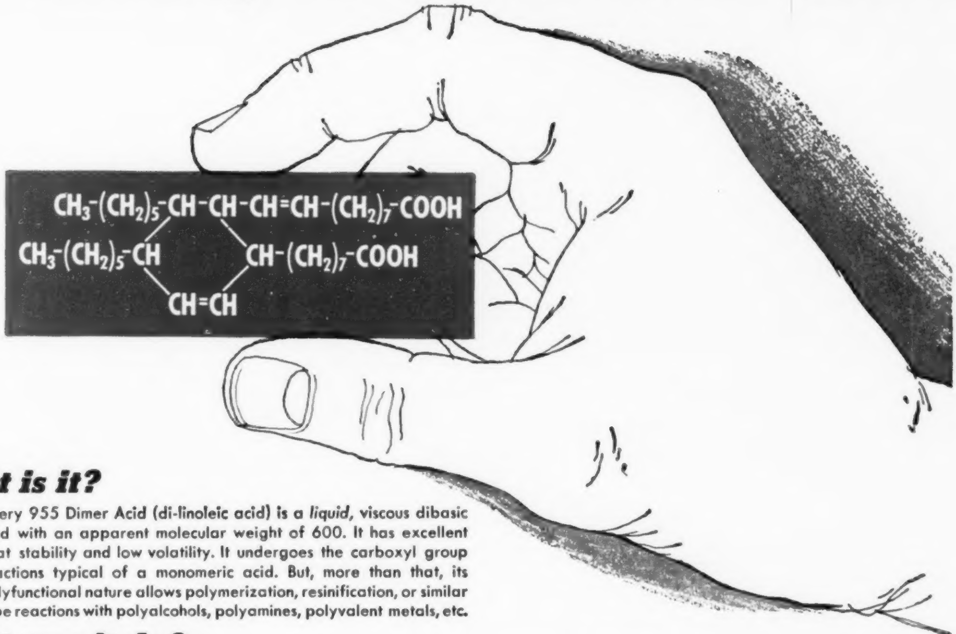

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ABOUT THE COVER

The two plants of the Foote Mineral Company shown on the front cover are intimately associated with both lithium hydroxide and lithium stearate used by lubricating grease manufacturers. As basic producers of lithium chemicals, Foote Mineral Company has worked closely with the lubricating grease industry in the past development and present quantity production of these raw materials required in the various formulations now being employed in multi-purpose lithium greases.

The larger aerial photograph shows the Foote chemical processing plant at Exton near Philadelphia, Pa. Note the new construction which together with current plans will greatly increase the lithium processing capacity this year.

Of equal significance is the smaller aerial photograph of the Kings Mountain, North Carolina, facilities of Foote Mineral Company. This project, which will be in production by mid-year, involves the largest known domestic source of high grade spodumene, from which lithium chemicals are derived. It represents an assured all-weather source of lithium-bearing ores to supply the Exton Plant.

LUBRICATE FOR SAFETY
- EVERY 1,000 MILES -

President's page

by Howard Cooper, President, N.L.G.I.

"Is industry selfish?"

Sure, industry is selfish. Why not? Industry is composed of human beings, and selfishness is a human quality. But is that necessarily bad? Selfishness need not be an evil force.

The automobile did not become a reality because of one man's altruistic desire to make something for his neighbor to enjoy. Henry Ford did not apply his mind and energy to create a car which could be made cheaply enough to reach low income homes, just because of his love for mankind. Ford and other industrialists expected a profit return; they hoped to make money that they might enjoy life more fully, and do other and bigger things with their earnings.

Where would be the enlightened development and the civilization of today, and the comforts and conveniences in our lives, without selfish motivation? The free enterprise spirit which has built the American way of life does not frown on selfishness of the right sort. The profit motive which bureaucracy and politics are endeavoring so vigorously to stifle is not ignoble.

If men had not been imbued with selfish aspirations, is it likely that there would be 39c safety razors, 10c light bulbs, and a can of soup for a dime? Or electric refrigerators, radio and television within reach of millions? And institutions which came into being, and have continued because of endowments—colleges, libraries, schools for the blind and crippled, orphanages, hospitals, research laboratories—to what extent would they exist, if ahead of the unselfishness of philanthropy there had not been selfish profit motivation?

Indeed, it is fortunate for all of us, our families and generations to follow, that men and groups of men (industries) have been spurred on by certain selfish interests to explore and experiment against the odds of discouragement, in search of something new or better. If industry is prohibited from making profits, it cannot engage in research or risk venture in the realm of unexplored ideas and improvements; it cannot design and build machinery to make products better and cheaper, for the benefit of more people.

Some say that government would and should take on these responsibilities. It has been seen how this has worked out in countries that practice nationalization in various forms. Others say that whether government or industry does the job, all individuals pay for it. This is not quite true. Of course, when these activities are wholly government sponsored all citizens certainly do pay through taxes, and get in return uninspired inefficiency. On the other hand, industry conducted developments are paid for by those who buy the products, yet everyone may benefit to the extent that the products of manufacture contribute to the economy and comfort of living.

The term "selfishness" when applied to industry should not be used loosely, but with proper interpretation. It is desirable that industry have incentive to create and improve processes and products; when incentive is withdrawn progress ceases, and the loss is shared by all. As long as complete monopoly is controlled, selfishness in industry will be kept well in hand; competition will take care of that.

Let it be observed that bureaucratic control which is being urged upon industry is not free from selfishness. Many revelations disclose that the selfishness in bureaucracy is sinister in character. It is important to preserve and encourage the selfishness represented by the spirit of free enterprise and the profit motive, while working to eliminate evil selfishness which would destroy the benefits that a free industry can bring to progress and to the comfort and happiness of mankind.

EVALUATION OF THE *Anti-Wear Properties*

ABSTRACT

The primary object of this investigation was to determine the applicability of the Navy Gear Wear Tester as a means for evaluating the anti-wear characteristics of synthetic low temperature greases to be used for the lubrication of brass-on-steel surfaces, and to supplement other bench test data by employing metallic combinations of dissimilar metals in the form of actual gears.

The paper describes the work done to develop the apparatus as a more suitable means for evaluating lubricants through a statistical treatment of data obtained on three greases during calibration. Basis the analysis of these data, which gave a desired spread of wear rate values, a control graph was established determining the maximum allowable difference between a run and check value for a valid evaluation of the anti-wear characteristics of a grease. In addition, a curve was developed which determined what significance could be attached to differences between the wear rates of two different greases by this test.

Tabular data on Air Force-Navy (AN) Government Specification greases evaluated on brass-on-steel test pieces are included, as well as correlative data obtained employing gear materials identical with those used in mechanical aircraft actuator screw feeds; these metals being phosphor bronze, 24ST aluminum, and SAE 4130 steel.

On the basis of the results presented it is concluded that the tester is suitable for the evaluation of greases; it lends itself as a sensitive means for determining the effects of additives on wear, and correlates with actuator mechanisms employing phosphor bronze nut-steel screw parts.

I. INTRODUCTION

Through the years, many types of equipment have been developed for use by laboratories in an effort to evaluate lubricants for anti-wear characteristics. Although these testers have been able to show differences between lubricants by comparative means, they have failed to evaluate lubricants with respect to their probable performance in specific applications. Some reasons for discrepancies can be attributed to the differences in materials used in the manufacture of the test pieces and in their geometry.

The Navy Gear Wear Tester to be described has met the problem of test piece geometry by using actual gears as test pieces. The simplicity and ease of operation of this apparatus, as well as its accuracy, have shown it to be particularly well suited for the evaluation of greases used in the lubrication of worm gear or nut screw mechanisms as found in aircraft type mechanical actuators. The sliding action of the helical gear surfaces also lends itself for possible correlation with applications other than that mentioned above; for instance, ball and/or roller bearing retainer wear, particularly where the retainers are of brass.

The Navy Gear Wear Tester was conceived and originally constructed during World War II by E. L. Welsh of the Research and Development Laboratory, U. S. Naval Ordnance Plant, at Indianapolis, Indiana, in order to supplement present bench-type wear tests available for brass-on-steel problems and to develop an improved tester, if possible, by using actual gears as test pieces. It was brought to the attention of the Texas Company through the Navy Department Bureau of Aeronautics because of joint military- industrial interest in methods of grease evaluation.[1]

Construction of this apparatus was undertaken by the Texas Company primarily to determine the applicability of the Navy Gear Wear Tester as a means for evaluating the anti-wear characteristics of synthetic low temperature greases

[1] *Work carried out for the Navy Bureau of Aeronautics at the Navy Engineering Experiment Station, Annapolis, Maryland, using the Navy Gear Wear Tester, is described in NEES Report C-3282-B, NA-582182 dated October 31, 1949.*

OF GEAR GREASES

by N. J. NINOS*
The Texas Company

and to obtain information for correlation purposes with full scale actuator mechanisms.

Test gears may be manufactured from any material considered suitable, the choice of materials being dependent on the particular correlation that is desired. In this investigation brass-on-stainless steel gear combinations were chosen first, since these materials were used in the original work performed by Naval Ordnance. In addition, phosphor bronze and 24 ST aluminum-on-SAE 4130 steel were employed for correlation with information gained in full scale aircraft actuator mechanism tests which utilize a bimetal nut-screw unit to impart linear motion. Some information was also obtained on SAE B-1112 steel against stainless steel on a limited number of greases.

II. EXPERIMENTAL WORK

A. DESCRIPTION OF APPARATUS

1. APPARATUS FOR GREASE TESTING

The test apparatus and procedure used in this work for the most part was based on drawings and a report received from the Indianapolis Naval Ordnance Plant via the Navy Department Bureau of Aeronautics[1]. Figure 1 shows an over-all view of the apparatus, which consists of a driving motor (A), a Vickers ½ Horse Power Hydraulic Variable Speed Transmission (B), and the Navy Gear Wear Fixture (C).

The power source for the apparatus delivers simple harmonic motion of 4.0 inches amplitude at 40 cycles per minute through crank(F), a leather ribbon[2], and drum (H), which oscillates the upper (brass) test gear approximately one revolution. Thus the two helical gears, each approximately one-half inch in diameter, are rotated together and placed under load by means of a seven-pound lead weight attached by a leather ribbon (G)[2] to drum (J), which applies a torque-load of approximately three and one-half inch-pounds to the test gears, opposing the motion of the crank arm in one direction and assisting in the other. A closer view of the Navy Gear Wear Fixture is shown in Figure 2.

A plastic cover, Figure 3, enclosing the apparatus has been found useful for keeping the gears dust-free during the course of testing, has aided in maintaining a fairly constant ambient air temperature (approximately 103° ± 5° F), and has allowed for easy visual inspection of the gears.

2. APPARATUS FOR OIL TESTING

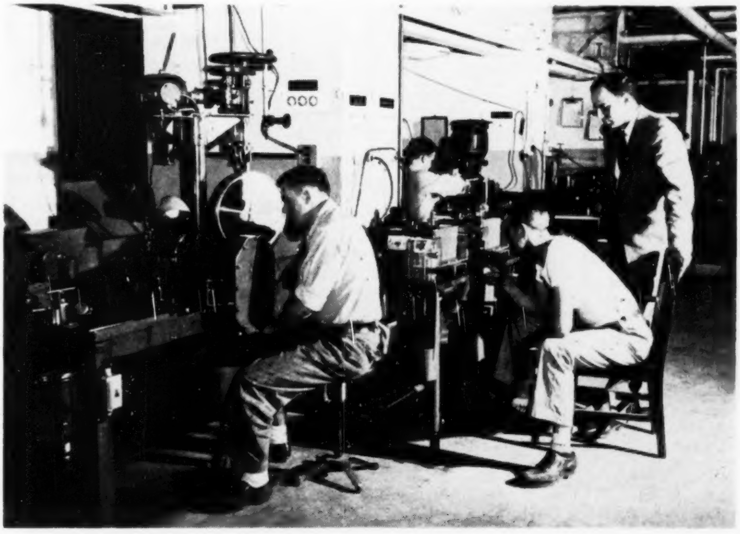
Figure 4 shows the apparatus as modified for this testing. A drop feed lubricator is used as a reservoir and a means for metering the lubricant to be tested. Approximately one drop of oil per 10 to 12 seconds is allowed to fall on the upper gear. The drop of oil both lubricates the gears and washes the brass wear particles into a receptacle below.

This modification of the apparatus is mentioned as a matter of interest; however, no data will be reported since the testing of oils is beyond the scope of the present paper.

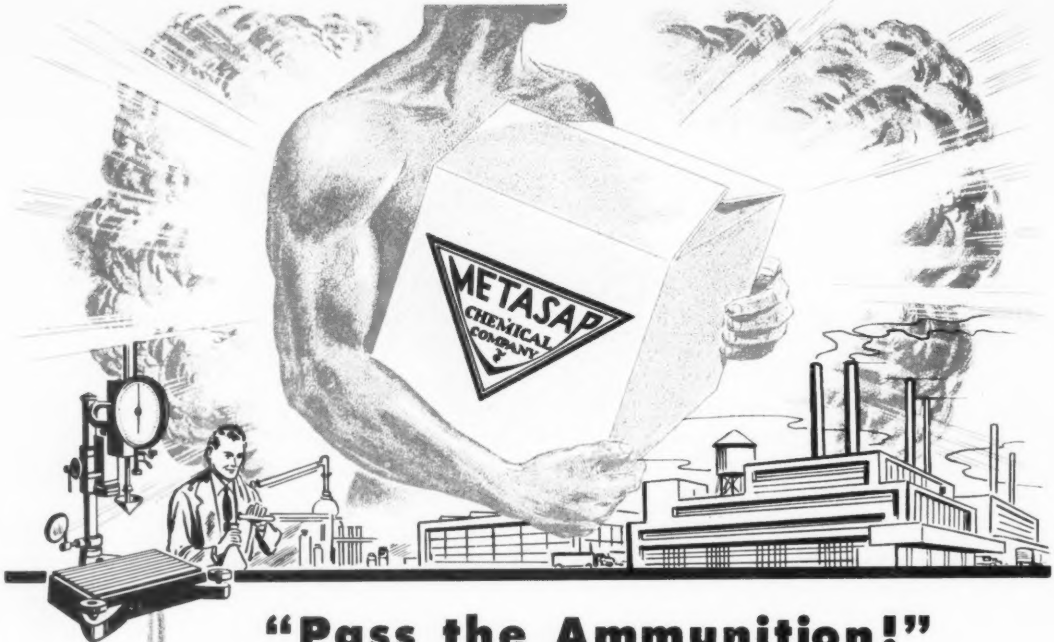
**At the present time the author is connected with SKF Industries.*

[1]*Naval Ordnance Report No.* T-647-18, *PJO* #224 *of* 4 *June* 1947.

[2]*In subsequent tests run,* ⅛" *nylon stranded line was used, which markedly reduced breakage at this point.*



In the Grease and Industrial Lubricants Testing Group Laboratory the author, extreme right, and a technician are checking the Navy Gear Wear Tester. Other personnel are conducting extreme-pressure tests.



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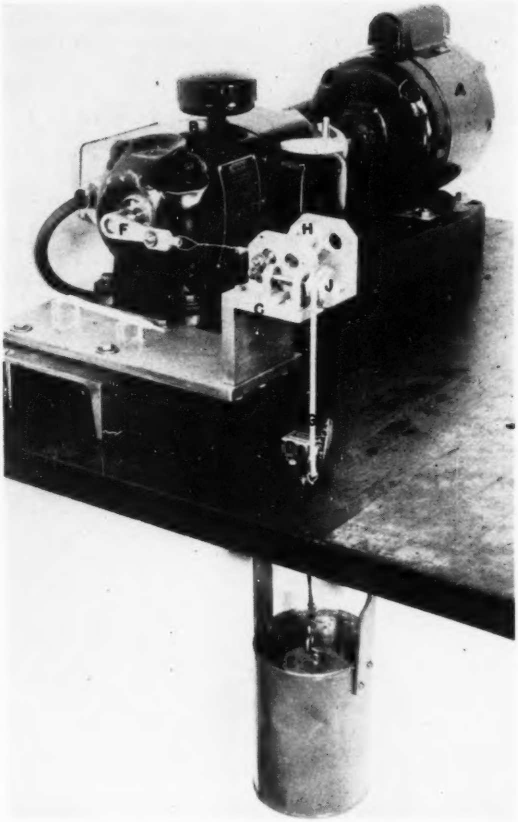

Figure 1
Navy Gear Wear Test Apparatus

B. PROCEDURE

A pair of brass and steel gears are cleaned by brushing with Stoddard Solvent and then dipped into a 1:1 solution of methyl alcohol and benzene. The gears are allowed to dry in air, weighed to 0.1 milligrams, and then placed in their respective positions on the apparatus.

When testing greases, approximately one gram of the test grease, representing an excess, is buttered on the gears and the seven-pound weight attached. As mentioned previously, the gears are oscillated at 40 cycles per minute for 17,000 cycles, or until gear tooth failure due to excessive wear occurs. Readings of ambient air temperature, and cycles completed (accumulated by counter D, Figure 1), are taken hourly, a single run of 17,000 cycles requiring approximately seven and one-half hours for completion. At the completion of the test, the gears are removed from the fixture, cleaned as before, and reweighed to determine weight loss.

The wear rate in milligrams weight loss for 10,000 cycles of operation is then calculated in order to facilitate the comparison of those lubricants which completed 17,000 cycles of operation with those that did not.

New test gears are used for each run made even though there is virtually no wear of the stainless steel gear as compared to the brass gear. Changing of both gears is practiced regardless of the wear involved in order to insure against "conditioning" of the metal surface with protective films, which would necessarily favor the test grease.

The gears used in this investigation[1] were made in accordance with drawings, and conformed to the metallurgical properties submitted by the Indianapolis Naval Ordnance Laboratory as shown in Table I, page 13. The gears, used by them in their original work and by the Naval Engineering Experimental Station at Annapolis, were coated with a black oxide and were surplus instrument gears.

C. RESULTS AND DISCUSSION

1. REPRODUCIBILITY OF THE APPARATUS

Before anti-wear evaluation of an extensive series of greases was begun, three greases were chosen, which in preliminary testing appeared to have three definite levels of

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[1]*The gears used in this work were manufactured by the Precision Gear and Machine Company, Inc., 2001 North Tryon Street, Charlotte 1, N. C., and were made without a black oxide coating to eliminate this variable.*

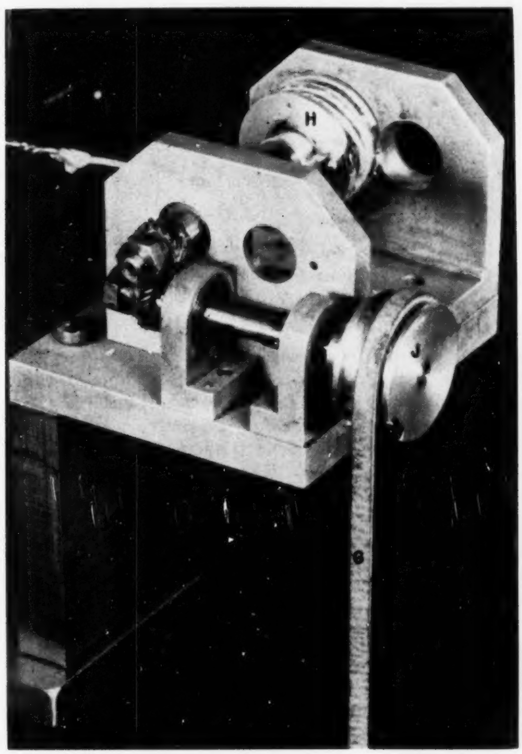

Figure 2
Navy Gear Wear Test Fixture

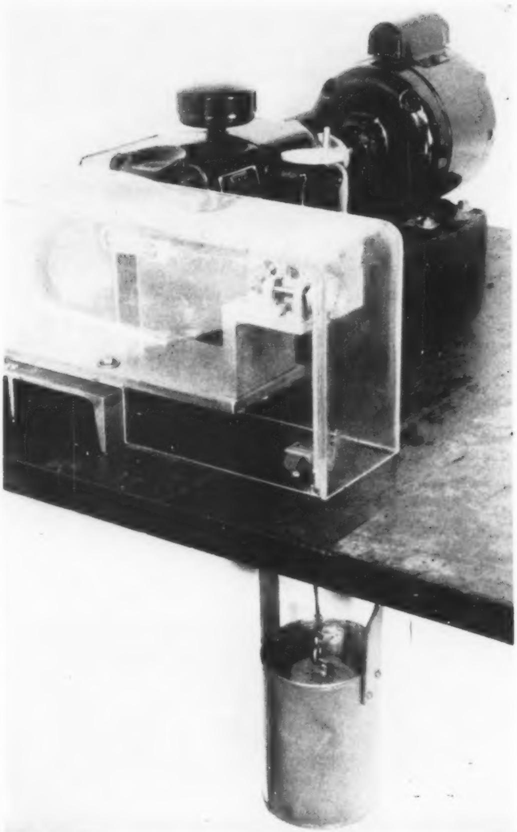

Figure 3
Navy Gear Wear Test Apparatus Completely Assembled for Grease Testing.

wear as indicated by the weight loss of the brass gear per 10,000 cycles of operation. Each of the lubricants were run for a minimum of nine runs and the standard deviation of an individual value[1] as well as the arithmetic mean determinated as shown in Table II, page 15. With this information, a control graph, Figure 5, Curve A, was developed which establishes for the average wear rate per 10,000 cycles of two successive runs the maximum allowable difference between the two runs for check purposes[2]. The average wear, basis two runs, determines the anti-wear characteristics of a grease.

Use of Curve A is exemplified by referring to Runs 1 and 2 for Greases I, E, and A as tabulated in Table II, page 15. As shown below, the actual difference calculated for two runs is well within the maximum allowable difference obtained from Curve A for each of the greases in question.

	Brass Gear Weight Loss Milligrams Per 10,000 Cycles		
Grease	I	E	A
Run No. 1	31.9	8.2	2.5
Run No. 2	29.8	11.2	2.3
Average	30.7	9.7	2.4
Maximum Allowable Difference From Curve A based on Average	10.0	5.2	2.1
Actual Difference Between Runs 1 and 2	2.1	3.0	0.2

From the precision obtained with this tester, basis all runs made for brass-on-steel, it is estimated that the majority of evaluations conducted in the 0 to 30 milligrams wear range (basis 10,000 cycles) will require only two consecutive runs.

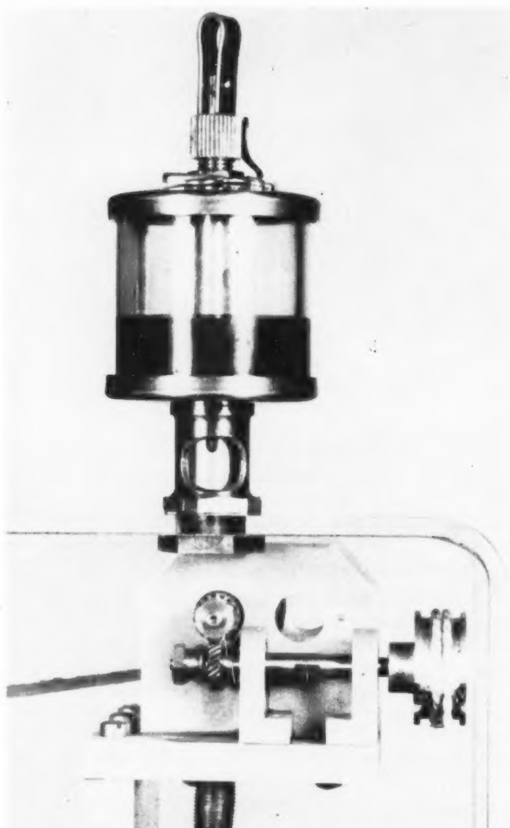

Figure 4
Navy Gear Wear Tester Showing Modification for Oil Testing.

[1] G. W. Snedecore's, "Statistical Methods", Third Edition, 1940
[2] E. L. Grant's, "Statistical Quality Control", First Edition, 1946.

TABLE I

METALLURGICAL ANALYSIS OF GEAR MATERIALS USED

Material	Naval Brass*	Stainless Steel	24 ST Aluminum*	Phosphor Bronze*	SAE-4130 Steel	SAE-B-1112 Steel*
Hardness Rockwell B	62	103	59	74	110	98
Approx. Per Cent Composition						
Cr	....	18	....	....	0.5	....
Ni	....	9	....	....	0.5	....
C	....	0.43	....	....	0.2	0.31
Si	....	1.0	....	....	0.2	0.1
Mn	....	0.5	0.7	....	0.5	0.5
Mg	....	....	1.5	....	....	....
Cu	61	....	4.0	93.9	....	....
Pb	2.3	....	....	....	....	....
Al	....	....	94.8	....	....	....
Zn	36.4	....	....	....	....	....
Sn	0.5	....	....	4.3	....	....
P	....	....	....	0.1	....	....

GEAR DATA

	Test Gear	Mating Gear
Pressure Angle	14-½°	14-½°
Pitch Dia. in.	0.4359	0.4769
Normal D.P.	64	64
No. Teeth	16	25
Helix Angle	55° L.H.	35° L.H.
Form	Involute	Involute
Root Dia.	0.400 ± 0.000 0.010	0.441 ± 0.000 0.010

*Test Gear on which weight loss was measured. There was virtually no wear on the mating gear.

The development and use of Curve B will be explained in the following sections.

2. METHOD FOR COMPARING GREASES

In order to determine whether or not a given evaluation or the average wear rate of one grease is significantly different from the results obtained on another grease, a statistical test, known as Student's "t," test, was used.[1] Briefly, the criterion may be expressed by the inequality:

$$(\bar{X}_a - \bar{X}_b) > 1.8\sqrt{\frac{\sigma_a^2}{N_a} + \frac{\sigma_b^2}{N_b}}$$

where $\bar{X}$ is the average value for N number of runs and σ is the standard deviation from the mean previously calculated. If the quantity $(\bar{X}_a - \bar{X}_b)$ is greater than the quantity $1.8\sqrt{\frac{\sigma_a^2}{N_a} + \frac{\sigma_b^2}{N_b}}$, then it can be concluded that $\bar{X}_a$ is significantly greater than $\bar{X}_b$. There is no significant difference if $(\bar{X}_a - \bar{X}_b)$ is less than the above-mentioned quantity.

Mathematics involved for computing Curve B of figure 5 follows:

1. $\bar{X}_a - \bar{X}_b > 1.8\sqrt{\frac{\sigma_a^2}{N_a} + \frac{\sigma_b^2}{N_b}}$

   for $N_1 = N_2 = 2$

2. $\bar{X}_a - \bar{X}_b > \sqrt{1.6\,\sigma_a^2 + 1.62\,\sigma_b^2}$

3. $(\bar{X}_a - \bar{X}_b)^2 > (1.6\,\sigma_a^2 + 1.62\,\sigma_b^2)$

   let $f = 1.62\,\sigma^2$

4. $(\bar{X}_a - \bar{X}_b)^2 > (f_a + f_b)$

[1] P. R. Rider's, "Modern Statistical Methods", First Edition, 1939.

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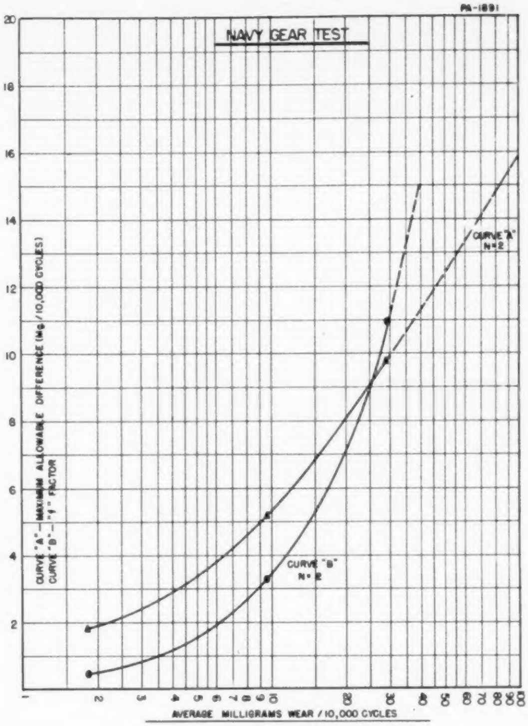

Figure 5

Curve B, Figure 5, was developed from the above expression to simplify the operation involved when comparing the evaluations of two greases for significance. The quantity "f" was calculated from the standard deviation of an individual value obtained from Table II and for N the number of runs equal to 2.

The use of this curve will be explained in the following section in connection with the evaluation of the test greases.

3. ANTI-WEAR EVALUATION OF VARIOUS GREASES

a. EVALUATION OF GREASES CONFORMING TO AIR FORCE-NAVY (AN) GOVERNMENT SPECIFICATIONS

A list of the various greases evaluated in this investigation is presented in Table III, page 16.

The AN-G Specification greases, evaluated in order of increasing wear rate are tabulated in Table IV, page 17. The tabulation shows statistically whether or not the difference in wear rate, measured for two greases and listed in the table, is significantly different. For example, a comparison between Greases A and B, and F and G is cited. As explained in the previous section of this paper, "Method For Comparing Greases", if the square of the difference between the two average wear rates (average of two runs) shown in Table IV as $(\bar{X}_a - \bar{X}_b)^2$ in greater than $(f_a + f_b)$ as obtained from Curve B, Figure 5, the average wear rates are significantly different. This is exemplified as follows:

TABLE II

NAVY WEAR TESTER

TEST RESULTS SHOWING REPRODUCIBILITY

(Brass Gear Weight Loss, Milligrams Per 10,000 Cycles)*

Grease Identification	I	E	A
Run			
1	31.9	8.2	2.5
2	29.8	11.2	2.3
3	29.8	10.0	2.1
4	29.5	8.8	1.3
5	32.2	7.7	1.9
6	28.1	11.8	0.9
7	23.8	10.0	1.9
8	27.2	9.4	1.5
9	27.0	8.2	1.9
$\overline{V}$	2.62	1.41	0.50
$\overline{X}$	28.8	9.5	1.8

$\overline{V}$ = Standard deviation of an individual value.

X = Arithmetic means of nine runs made.

*All runs completed successfully 17,000 cycles of operation, the greases being subjected to a seven-pound load.

Chemical and Engineering Laboratories Building at The Texas Company's Beacon Research Laboratories, Beacon, New York.

TABLE III

IDENTIFICATION OF VARIOUS GREASES EVALUATED

Grease	AN-G-No. [1]	Type Grease	Consistency A.S.T.M. Worked at 77°F.
A	25	Low Temperature (Low Volatility Type)	275
B	25	Low Temperature (Low Volatility Type)	291
C	25	Low Temperature (Low Volatility Type)	286
D	25	Low Temperature (Low Volatility Type)	277
E	25	Low Temperature (Low Volatility Type)	289
F	5a	High Temperature	278
G	15	Aircraft General Purpose	261
H	3a	Low Temperature	330
I	10	Low Temperature + E.P.	350**
J	10	Low Temperature + E.P.	310
O	25 Type	Low Temperature + E.P.	299
P	25	Low Temperature + Cu Corrosion Inhibitor	286
Q	25 Type	Low Temperature + High Molecular Weight Polymer	298
R	25 Type	Low temperature having additives of Greases P & Q	290
S	25	Low Temperature (Low Volatility Type)	290
T		Silicone	320
U		Carbon Black Silicone	298
V		Silicone	251
W		Silicone	340

**Converted from Miniature Penetration[2] of 188.

[1] *Army-Navy Government Specification Number.*

[2] *G. Kaufman et al "Miniature Penetrometer for Determining the Consistency of Lubricating Grease", Industrial Engineering Chemistry*, 1-15-39, pages 108-110. *Also see A.S.T.M. D-2 Standards on Petroleum Products and Lubricants, Appendix I, Nov.* 1949, *p.* 1309.

TABLE IV

WEAR COMPARISON OF LUBRICANTS MEETING AN-G SPECIFICATIONS

(BRASS-ON-STEEL)

(SEVEN-POUND LOAD)

Grease	Type Grease	AN-G-No.	$\bar{x}$ Avg. Weight Loss, Brass Gear In Mg./10,000 Cycles	f_x	Significance of Results $(\bar{x}_a - \bar{x}_b)^2$	Significance of Results $f_a + f_b$	Significance of Results Remarks
A	Low Temperature (Low Volatility Type)	25	1.8	0.5			
					2.55	1.4	*
B	Low Temperature (Low Volatility Type)	25	3.4	0.9			
					0.09	2.0	**
C	Low Temperature (Low Volatility Type)	25	3.7	1.1			
					5.29	3.2	*
D	Low Temperature (Low Volatility Type)	25	6.0	2.0			
					12.25	5.2	*
E	Low Temperature (Low Volatility Type)	25	9.5	3.2			
					29.16	8.4	*
F	High Temperature	5a	14.9	5.2			
					1.95	10.9	**
G	Aircraft General Purpose	15	16.3	5.7			
					57.76	14.2	*
H	Low Temperature	3a	23.9	8.5			
					24.01	19.3	*
I	Low Temperature — E.P.	10	28.8	10.8			
					31.36	24.1	*
J	Low Temperature — E.P.	10	34.4	13.2			

**Difference between two successive results in column $\bar{x}$ of above table is significant: i.e. Grease A and B.*

***Difference between two successive results in column $\bar{x}$ of above table is insignificant: i.e. Grease B and C.*

NOTE: If $(\bar{x}_a - \bar{x}_b)^2$ is greater than $f_a + f_b$ then results are significantly different. No significance is attached to difference if the reverse is true. All greases successfully completed 17,000 cycles of operation.

Grease	$\bar{X}$ Wear mg./10,000	f From Curve B	$(\bar{X}_a - \bar{X}_b)^2$	$f_a + f_b$
A	1.8	0.5		
			2.55	1.4
B	3.4	0.9		
F	14.9	5.2		
			1.95	10.9
G	16.3	5.7		

Since $(\bar{X}_A - \bar{X}_B)$, the square of the difference between the two average wear rates for Greases A and B is 2.55, and the quantity $(f_A + f_B)$ as obtained from Curve B, Figure 5 is 1.4, the average wear rates for these two greases are significantly different. By the same method it is shown that there is no significant difference between the relative ratings of Greases F and G, since the value $(\bar{X}_F - \bar{X}_G)^2$ in being equal to 1.95 is appreciably less than the quantity $(f_F + f_G)$, which is 10.9.

b. EFFECTS OF ADDITIVES ON WEAR

Some information has been developed which demonstrates the effects of additives on the wear of brass stainless steel surfaces. Table V, page 18, lists for comparison purposes, data obtained on greases with and without extreme pressure additives, and also on variations of an AN-G-25 product.

The results obtained for Greases H and E (Non-E.P. Lubricants), in comparison with those obtained for Greases J and O (lubricants containing E.P. agents) indicate markedly that the extreme pressure agents employed increase wear for the metallic combination tested, both in mineral oil greases and in synthetic ester greases. A probable explanation for this phenomenon may be attributed to corrosive wear resulting from a chemical reaction of the extreme pressure agent with the brass gear.

TABLE V

WEAR RATE AS AFFECTED BY ADDITIVES (7-POUND LOAD)

Grease Identification	Government Specification	Additive Content and Type	Avg. Wear Rate Brass Gear mg/10,000 Cycles
H	AN-G-3a	No. E.P. Agent	23.9
J	AN-G-10	Grease H with E.P. Agent	34.4
E	AN-G-25	No. E.P. Agent	9.5
O	AN-G-25 Type	Grease E with E.P. Agent*	17.7
P	AN-G-25 and 2-134	Grease E with Cu Corrosion Inhibitor	4.4
Q	AN-G-25 Type	Grease E with High Molecular Weight Polymer	4.0
R	AN-G-25 Type	Grease E with Cu Corrosion Inhibitor + High Molecular Weight Polymer	2.9
S	AN-G-25	Similar to Grease E But with different ester in the Oily Component	14.8

NOTE: All greases completed 17,000 cycles of operation under seven pounds load.
**Also contains a copper corrosion inhibitor, however, the grease becomes corrosive to copper after a storage period.*

In order to determine the sensitivity of the apparatus as to its ability to detect the presence of additives contained in a base grease, and/or changes in chemical composition, variations of Grease E were evaluated, the results of which are also shown in Table V. (Greases O to S). The results indicate that this tester is able to differentiate between a base grease and the same product containing small amounts of commonly used additives.

As mentioned before, the introduction of an extreme pressure additive in Synthetic Grease O increased the wear of the brass gear as compared to the wear measured for the non-additive base Grease E. Introduction of a copper corro-

TABLE VI

CORRELATION OF RESULTS
NAVY GEAR WEAR TESTER versus LARGE AIRCRAFT ACTUATORS

GREASE IDENTIFICATION	I	E
	AN-G-10	AN-G-25
1. NAVY GEAR WEAR TEST	SEVEN-POUND LOAD	
Avg. Weight Loss Brass Gear, mg./10,000 Cycles	28.8	9.5
Avg. Weight Loss Phosphor Bronze, mg./10,000 Cycles	9.5	1.5
2. FULL-SCALE AIRCRAFT ACTUATOR TEST UNDER TENSION LOAD		
a. TENSION LOAD POUNDS	TOTAL CYCLES COMPLETED	
1500*	2877	7582
Start 1500 and Reduced to 1000†	1725	5747
1000‡	4229	10442
b. TENSION LOAD POUNDS	PHOSPHOR BRONZE NUT WEAR: mg./1000 cycles weight loss	
1500*	408	90
Start 1500 and Reduced to 1000†	105	15
1000‡	163	264

**Cycles and nut weight loss noted were average of two runs.*
†Actuators were operated with load of 1500 pounds until current drawn on retractive stroke became excessive. This ordinarily constituted the completion of a run. However, in these cases load was reduced to 1000 pounds and additional cycles were completed, the total being reported. Only one run made for each lubricant.
‡Only one run completed for each lubricant before worn mechanism necessitated termination of work.

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sion inhibitor, Grease P, reduced the amount of wear to approximately one-half the amount measured for the base Grease E, thus substantiating the discussion given on the phenomenon of corrosive wear when using E.P. agents. Addition of a high molecular weight polymer (Grease Q) also tended to reduce the rate of wear, possibly through its tendency to increase the viscosity of the synthetic oily component, which would tend to bolster the film viscosity (and thickness) at the operating temperature. Grease R, containing both a corrosion inhibitor and a high molecular weight polymer gave the lowest wear rate value of all lubricants tested. Grease S, similar to Grease E but with a different ester in the oily component, showed a higher wear rate than the original formula.

It should be emphasized that the above differences shown by the subject tester, though significantly different statistically, may not be significant in terms of field service, i.e., a whole group of lubricants may perform with substantially equivalent results even though slight differences are detectable with a sensitive laboratory test. Furthermore, no laboratory test set-up can include all the variables which may affect the performance in aircraft of complicated mechanisms such as actuators; therefore, full-scale flight tests are necessary for a final answer.

4. CORRELATION OF NAVY GEAR WEAR TEST RESULTS WITH FULL-SCALE AIRCRAFT ACTUATOR TESTS

a. LARGE AIRCRAFT ACTUATORS

Table VI, page 18, summarizes the correlation between results obtained from the Navy Gear Wear Tester utilizing brass-stainless steel, and phosphor bronze-SAE 4130 steel gear combinations and full-scale aircraft type actuators which employ a rotating SAE-4130 steel screw together with a phosphor bronze nut to impart linear motion.

The full-scale actuators used in this work were found not to be suitable for screening test purposes since the nature of the equipment introduced a number of mechanical and electrical difficulties. In addition, the length of time for the accumulation of approximately 10,000 cycles was prohibitive, being in the neighborhood of several weeks. However, the results obtained indicate Grease E to be more suitable than Grease I for bronze-steel lubrication, basis the greater endurance shown by the actuators lubricated with the former lubricant in all runs conducted. These data are in agreement with Navy Gear Wear results which evaluated Grease E as having a lower wear rate than Grease I.

Although the actuator phosphor bronze nut weight loss measured when testing at 1000 pounds tension load shows a discrepancy as compared to 1500 pounds load, in general, the results obtained on the two lubricants are in agreement with the wear data obtained using both brass-stainless steel and phosphor bronze-SAE 4130 steel test piece combinations on the Navy Gear Wear Tester.

b. SMALL AIRCRAFT ACTUATORS

In conjunction with the work discussed in the previous section on large aircraft actuators, a considerable amount of work was performed to determine the suitability of Grease E as a lubricant for use in small aircraft actuators. These actuators utilize a 24ST aluminum nut and SAE 4130 steel screw to impart linear motion.

The test results obtained and tabulated in Table VII, page 22, on the Navy Gear Wear Tester on 24ST aluminum-SAE 4130 steel helical gear combinations using 7 and 14 pounds loading and the full-scale actuator tests performed indicate that there is no apparent correlation; in fact, the ratings for Grease E and the E.P. greases I and J are reversed for the gear wear tests. It is probable, however, that the discrepancy lies in the fact that the seven-pound applied

Figure 6

Multiple Navy Gear Wear Test Rig

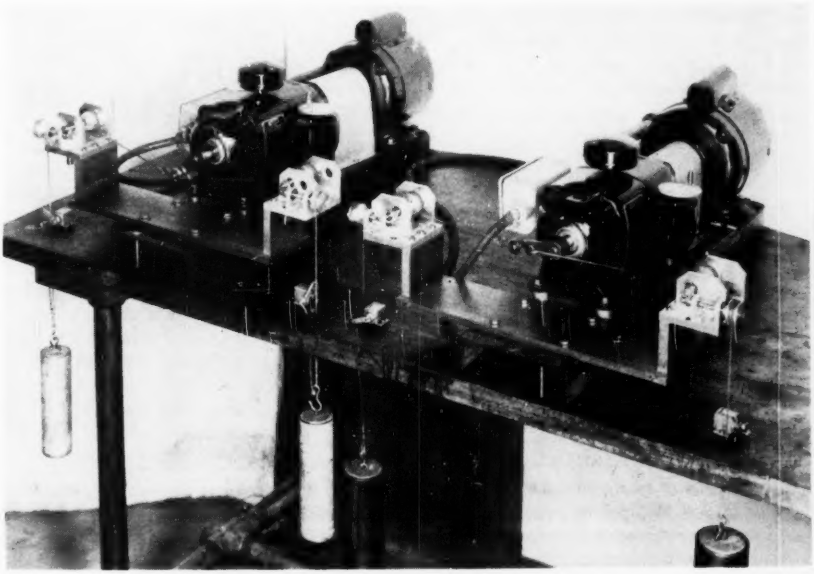

TABLE VII

CORRELATION OF RESULTS
NAVY GEAR WEAR TESTER versus SMALL AIRCRAFT ACTUATOR

Grease Identification	E	I	J
1. NAVY GEAR WEAR TEST			
Avg. Weight Loss 24ST Aluminum Gear, mg./10,000 cycles			
7-pound load	3.0	6.3	4.8
14-pound load	4.6f	19.9f	34.3f
2. FULL-SCALE SMALL AIRCRAFT ACTUATOR TESTS			
Cyclic spring loading under compression and tension conditions, 100-pound load)			
Average Values for Number Runs	4	3	1
24ST Aluminum Nut Weight Loss, mg.	283	14	12
Cycles Completed	5,300	40,000*	18,205
Nut End Play Increase, in.	0.022	0.000	0.002
Wear Rate mg./1000 cycles	53.40	0.35	0.67

**Test duration was 40,000 cycles of intermittent operation, one minute on and four minutes rest in order to cool.*
fDenotes failure of the Aluminum gear prior to completion of 40,000 cycles.

TABLE VIII

NAVY GEAR WEAR TEST FIXTURES — REPRODUCIBILITY BETWEEN FIXTURES
PROPOSED MIL-G CONDITIONS

	Five-Pound Lead — 6000 Cycles							
Grease Identification	A				I			
Gear Fixture	1	2	3	4	1	2	3	4
N	4	4	4	4	8	8	8	8
$\bar{X}$	0.50	0.55	0.55	0.53	14.16	12.99	14.26	13.51
σ'	0.51	0.41	0.42	0.36	1.45	1.43	1.95	1.65
$\bar{X}$/1000 Cycles	0.1				2.3			
MIL-G-Spec. Max. Wear $\bar{X}$/1000 Cycles	2.5							
	Ten-Pound Load — 3000 Cycles							
N	4	4	4	4	8	8	8	8
$\bar{X}$	2.60	2.43	2.58	2.65	16.83	15.91	15.65	16.05
σ'	0.42	0.59	0.97	0.92	1.21	1.64	1.48	1.51
$\bar{X}$/1000 Cycles	0.9				5.4			
MIL-G Spec. Max. Wear $\bar{X}$/1000 Cycles	3.5							

N = Number of runs made.

$\bar{X}$ = Average total brass gear wear, milligrams.

σ' = Standard Deviation per run.

$\bar{X}$/1000 Cycles = Average Brass Gear Wear, Milligrams per 1000 cycles.

Precision of each gear fixture and reproducibility between fixtures was established with Grease I on the basis of eight runs. Grease A was included to obtain additional data on a lubricant having a low wear rate and it was statistically established that four runs were enough for an analysis in view of the excellent results previously obtained with this grease under original Naval Ordnance Test conditions.

load on the gear fixture is subjecting the gear teeth to a higher pressure than is encountered on the actuator screw thread. Theoretically, only point contact exists between the surfaces of the helices while there is a considerable area of contact in a nut-screw unit.

It is of interest to note that although the wear measured at failure for the alumnium gears appears to be low in comparison to the weight loss measured for a brass gear at failure, the actual volume of metal removed from the aluminum gears is comparable to that from the brass gear. This is explained by the fact that aluminum is a lighter metal than brass, as shown from representative unused gear weights of 1.0897 and 3.2882 grams, respectively, for these materials.

3. MISCELLANEOUS WORK

In order to expedite future lubricant evaluations, four Navy Gear Wear Testers have been built and mounted as shown in Figure 6, page 21. It is planned to use these testers interchangeably, especially since the proposed MIL-G-Specification procedure[1] (Military Grease Specification) requires four runs to be made on the test grease, the average of which constitutes an evaluation.

Briefly, the procedure consists of a break-in period: wear of the brass gear (mating with a stainless steel gear), after 1500 cycles of oscillation at 50 cycles per minute under a five-pound load and lubricated with a commercial grade of di-2-ethyl-hexyl sebacate, shall not exceed 2.0 milligrams. If the loss is within this limit the gears are lubricated with the test grease for 6000 cycles under a five-pound load; the brass gear wear not to exceed 2.5 milligrams per 1000 cycles. Finally, the test is run for 3000 cycles under a ten-pound load; the maximum wear measured not to exceed 3.5 milligrams per 1000 cycles. Interchangeable use of the testers appears justifiable in view of the good precision and reproducibility statistically established on two greases A (AN-G-25) and I (AN-G-10). The amount of wear realized with the two lubricants chosen represents two extremes of wear for commercially used aircraft greases, indicating the sensitivity of the testers. As shown in Table VIII the average wear obtained on the brass gear in milligrams per *1000* cycles with a five and ten-pound load respectively was 0.1 and 0.9 for Grease A, and 2.3 and 5.4 for Grease I. By comparison with the maximum allowable wear proposed by the MIL-G-Specification of 2.5 and 3.5 milligrams per 1000 cycles with a five and ten-pound load respectively, it is shown that Grease A is well within the proposed specification limits, while Grease I does not conform.

In addition, results on the four units obtained under original Naval Ordnance conditions, as shown in Table IX indicate that reproducibility between units is also good, basis this method. Results obtained with Greases E, I and J on the four units are in line with previous results on fewer units using brass-stainless steel gears. In addition, a limited amount of work has been done (see Table IX) using phosphor bronze-SAE 4130 steel, 24ST aluminum-SAE 4130 steel, and SAE B1112 steel-stainless steel helical gear combinations.

[1]*Proposed MIL-G-Specifications for "Grease, Aircraft and Instruments, for Low and High Temperatures" (drafted dated 17 October 1949), and "Grease, Aircraft Gear and Actuator Screw for Low and High Temperatures" (drafted dated 7 November 1949).*

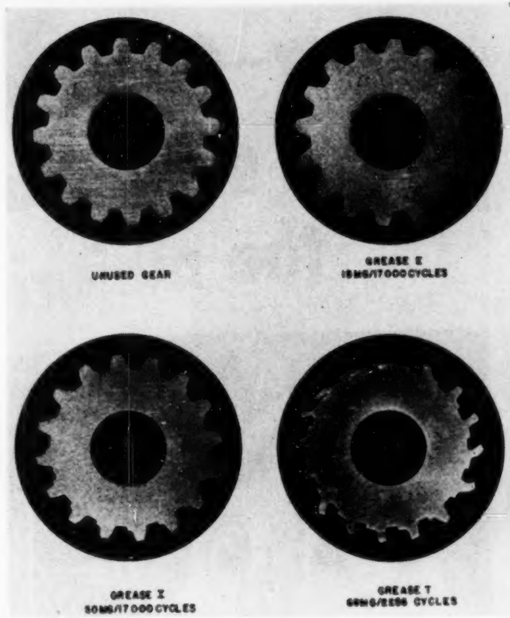

Figure 7

Helical Brass Gears (6X)
Tested on Navy Gear Wear Fixture

It is of interest to note that Greases E and J had equivalent low wear rates as compared to a higher rate for Grease I when evaluated using phosphor bronze—SAE 4130 steel and 24ST aluminum-SAE 4130 steel helical gear combinations. However, Grease I appeared to have better anti-wear characteristics than either Greases E or J when evaluated using SAE B 1112 steel-SAE 4130 steel helical gear combinations. The latter metallic combination (steel-on-steel) was run on units III and IV, subjecting the gears to a 14-pound load for 40,000 cycles. This procedure was followed since, under the regular test procedure, wear of the gears measured was insignificantly small.

Table X, page 26, compares the several lubricants tested employing the first three metallic combinations aforementioned under 7 and 14-pound loads. From these results, which were obtained by averaging the weight losses measured from at least one run on two different units, it can be seen that Greases E, I and J are in the same order of relative rating as when tested under seven pounds of load.

As a matter of interest, results obtained on four Silicone Greases T, U, V and W respectively, have been included in this investigation.

High wear values obtained, as shown in Table X, page 26, were considerably more erratic than for lower values of wear. For the most part erratic values were attribued to the excessively high weight losses of the test gear, which occurred from rapid wear plus gear tooth breakage. Usually this occurred in a few thousand cycles of operation, thus concluding the test.

End views of the helical test gears, which appear as spur gears through the Bakelite mounting, as shown in Figure

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TABLE IX

REPRODUCIBILITY BETWEEN TEST UNITS

Load, lb. Gear Material Combination		7 Brass*-Stainless Steel				7 Phosphor Bronze*-SAE 4130 Steel				7 24ST Aluminum*SAE 4130 Steel				14 SAE B1112 Steel*-Stainless Steel**			
Grease Identification	Unit No.	Milli-grams Weight Loss	Cycles Completed	Mg. Weight Loss Per 10,000 Cycles	Average Mg. Weight Loss Per 10,000 Cycles	Milli-grams Weight Loss	Cycles Completed	Mg. Weight Loss Per 10,000 Cycles	Average Mg. Weight Loss Per 10,000 Cycles	Milli-grams Weight Loss	Cycles Completed	Mg. Weight Loss Per 10,000 Cycles	Average Mg. Weight Loss Per 10,000 Cycles	Milli-grams Weight Loss	Cycles Completed	Mg. Weight Loss Per 10,000 Cycles	Average Mg. Weight Loss Per 10,000 Cycles
E	I	17.1	17657	9.7		2.3	17000	1.4		4.5	17000	2.6					
		19.3	19712	9.8													
	II	23.8	17000	14.0		2.7	17000	1.6		6.0	17000	3.5					
		22.2	19713	11.3													
	III	20.1	17000	11.8										16.7	45025	3.7	
		20.8	17033	11.9													
	IV	26.1	17000	15.3										21.6	45021	4.8	
		24.1	17024	14.1													
					12.9				1.5				3.0				4.4
I	I	60.5	17000	35.6		14.0	17000	8.2		11.0	17000	6.5					
		54.5	17000	32.1													
	II	64.4	17000	37.8		18.3	17000	10.8		10.6	17000	6.2					
		64.2	17000	37.8													
	III	50.1	17011	29.3										6.0	4000	1.5	
		63.9	17604	36.3										8.9	4000	2.2	
	IV	60.0	17011	35.2										10.7	4000	2.7	
		59.7	17604	33.9										14.4	4000	3.6	
					34.8				9.5				6.3				2.3
J	I	48.0	17103	28.1		2.6	17026	1.5		7.6	17000	4.5					
		45.0	17058	26.4													
	II	47.8	17000	27.8		3.9	17026	2.0		8.8	17000	5.2					
		63.5	17058	37.3										15.9	4000	4.0	
	III	37.8	17000	21.9													
		45.1	17000	26.5										16.2	4000	4.5	
	IV	43.7	17000	25.7													
		37.1	17000	21.8													
					26.9				1.9				4.8				4.3

**Test gear; milligrams weight loss is for this gear only. Virtually no wear measured for steel gears used (usually 0.1 to 0.2 milligrams per total cycles).*

***Units III and IV are being exclusively used for steel-on-steel testing. Wear obtained under regular conditions is insignificantly small, therefore, these tests are run using 14 pounds load.*

NOTE: Machine II original apparatus.

TABLE X

NAVY GEAR WEAR TESTER

AVERAGE WEAR RATES OBTAINED FOR SEVERAL LUBRICANTS EMPLOYING FOUR METALLIC COMBINATIONS

	7-Pound Load			14-Pound Load		
Greases Tested	Mg. Wt. Loss	Cycles Completed	Mg. Wear Per 10,000 Cycles	Mg. Wt. Loss	Cycles Completed	Mg. Wear Per 10,000 Cycles
			I. BRASS-STAINLESS STEEL			
E	21.6	17,705	12.2	72.2	13,294	55.4 f
I	59.6	17,126	34.8	28.5	3,702	76.9 f
J	45.9	17,063	26.9	62.2	7,362	85.0 f
T	78.5	1,511	519.5 f	....	....	....
U	80.2	3,460	231.8 f	....	....	....
V	64.9	1,169	555.2 f	....	....	....
W	121.2	1,954	620.2 f	....	....	....
			II. PHOSPHOR BRONZE-SAE 4130 STEEL			
E	2.5	17,000	1.5	15.0	57,823	2.7
I	16.1	17,000	9.5	40.3	26,552	15.2 f
J	3.3	17,026	1.9	17.9	28,766	6.3 f
T	40.4	16,622	24.3 f	....	....	....
U	13.0	17,000	7.6	....	....	....
V	8.4	17,000	4.9	....	....	....
W	6.2	17,064	3.6	....	....	....
			III. 24 ST ALUMINUM-SAE 4130 STEEL			
E	5.2	17,000	3.0	10.7	23,265	4.6 f
I	10.8	17,000	6.3	23.3	11,704	19.9 f
J	8.2	17,000	4.8	14.1	4,177	34.3 f
T	13.9	264	526.5 f	....	....	....
U	28.0	191	1466.0 f	....	....	....
V	18.0	717	251.0 f	....	....	....
W	21.8	287	760.0 f	....	....	....
			IV. SAE B 1112-STAINLESS STEEL			
E	....	....	....	18.2	45,023	4.4
I	....	....	....	10.0	40,000	2.3
J	....	....	....	16.0	40,000	4.3
T	....	....	....	20.0	63	3174.6*
U	....	....	....	25.3	134	1888.0*
V	....	....	....	12.4	1,534	80.8*
W	....	....	....	4.5	5,098	8.8*

NOTE: All wear rates given are an average of at least one run on each of two machines.

f Denotes failure of the test gear as in Figure 7. Gear tooth breakage also resulted in erratic weight losses.

**These runs were stopped prematurely due to gear tooth binding which caused the apparatus to stall. This was not due to the gear teeth bending and breaking as in f. The "binding" phenomenon appears characteristic of the silicone lubricants on the steel-steel combination used.*

7, present several degrees of gear wear as obtained when lubricating with Grease E, I, and Silicone Grease T. These are listed in order of increasing wear. The loaded edge of each gear tooth face shows the indentation caused by wear, and it can be seen to progress deeper into the tooth as greases of lesser wear protection are tested. The lower right figure shows the gear teeth to be bent over, which is typical of gear tooth failure caused by rapid wear.

From these data it appears that silicones give much higher wear when used for lubrication of either brass of SAE B 1112 steel on stainless steel, or for 24 ST aluminum-on-SAE 4130 steel. The runs made on these greases using phosphor bronze-SAE 4130 steel are somewhat surprising since they indicated a low wear rate and were not in line with

results obtained employing brass-on-stainless steel gears*. In addition, it appears that the results obtained on the silicone type greases by the Navy Gear Wear Test method are generally in direct agreement with results obtained by the Naval Research Laboratory[1] in their work on silicone fluids in which they used a manually-operated one-inch flat, cylindrical and polished metal slider upon a lubricant-covered, flat, polished metal plate. Their qualitative results are listed as follows:

		Lubrication Rating	
Slider	Plate	Silicone Fluid (DC Series 500)	Corresponding Petroleum Fluid (NS-1047)
Cold Rolled Steel	Aluminum	Bad	Good
Cold Rolled Steel	Stainless Steel	Bad	Good
Brass	Stainless Steel	Doubtful	Doubtful
Bronze	Stainless Steel	Doubtful	Good

The work recently published by Currie and Hommel on organopolysiloxanes as lubricants for various pairs of bearing materials, using the Falex machine, also confirm the above data[2].

*A probable explanation for the lower wear with phosphor bronze is that these gears are harder than the brass gears. Tests on silicone greases at the Naval Research laboratory have shown best results with ball bearings using bronze retainers rather than softer brass ones.

[1] "Dimethyl-Silicone-Polymer Fluids and Their Performance Characteristics in Hydraulic Systems", by Fitzsimmons, Pickett, Militz and Zuisman, Transactions, ASME, 68 No. 4, 361-369(1946).

[2] Currie, C. C., and Hommel, M. C. "Lubricating characteristics of the Organopolysiloxanes Under Boundary Conditions", presented before the Division of Petroleum Chemistry, American Chemical Society, Houston Meeting, March 26-30, 1950 at the Symposium on Synthetic Lubricating Oils.

SUMMARY OF RESULTS

On the basis of the work done in this investigation and the statistical treatment of the data obtained, the following conclusions are drawn:

1. From the precision and the spread of the levels of rating for the several greases tested using brass-on-stainless steel gears, it is shown that the Navy Gear Wear Tester affords a sensitive means of evaluating the anti-wear characteristics of greases for brass-on-steel applications; also this equipment appears promising for evaluating lubricants using other bimetallic combinations.

2. The apparatus is useful for determining the effects of various additives on the wear rates of greases: E.P. agents are indicated to cause increased wear on brass-steel and bronze-steel combinations.

3. Navy Gear Wear Tests, using gears of brass or phosphor bronze on steel, show good correlation with tests on full-scale large aircraft actuators which utilize a phosphor bronze-steel screw unit to translate motion: the limited work done using 24ST aluminum-on-steel shows no correlation with tests on small aircraft actuators which employ a nut-screw of the same metal combination to translate motion.

4. The results obtained on the silicone greases indicate their poor lubricating properties for brass-steel, 24ST aluminum-steel and steel-on-steel applications: however, fairly low wear rates were obtained with the silicones when lubricating phosphor bronze-steel gear combinations.

ACKNOWLEDGEMENTS

The writer wishes to thankfully acknowledge the assistance of R. S. Barnett in the performance of the original work through his constructive criticism; and F. H. Herdt in the maintenance of the apparatus and for supervising many of the tests run.

ANALYTICAL METHODS FOR *Hydroxy-Acid Greases*

The hydroxy fatty acids used industrially are those derived from castor oil. The hydroxy-acid derived from castor oil is known as ricinoleic acid or 12-hydroxy-9-octadecenoic acid. In order to prepare more mechanically stable and higher melting point greases, this product is usually hydrogenated to 12-hydroxystearic acid. From this fatty acid are usually prepared the corresponding sodium, lithium, calcium, and aluminum soaps. These soaps are used in the formulation of industrial greases in amounts varying between ½% and 15% of the weight of the finished grease. Much of this subject matter has found an important place in the patent literature in the past decade. It has been recognized in industry that these soaps contribute important and very desirable properties to many of the greases in which they form a very salient part of the formulation.

Because of the above conditions it has become necessary to identify frequently the presence of hydroxy fatty acid soaps in industrial greases. In order to attain this end it obviously becomes necessary to effect a separation of the hydroxy fatty acid from first, the petroleum oil, and second, the other fatty acids which might be present. Solubility studies of these various fatty acids and hydroxy fatty acids were made in various types of solvents with the objective in view of effecting their separation by preferential solubilities. The solubility studies revealed the following facts:

1) 12-Hydroxy stearic acid is insoluble in heptanes at 25° C.

2) Stearic, palmitic and myristic acids are soluble in heptanes at 25° C.

3) 12-Hydroxystearic acid is soluble in 95% ethanol at 25° C.

4) Stearic, palmitic and myristic acids are soluble in 95% ethanol at 25° C.

In addition to the above, studies were made upon the action of the lower aliphatic alcohols as solvents for 12-hydroxystearic acid. This product in its isolated form was found to have solubilities as follows:

5) Insoluble in hot or cold petroleum ether.

6) Soluble in hot or cold 99% isopropyl alcohol.

7) Soluble in isopropyl alcohol to which 50% of water was added, after which it clouded, but again cleared on heating to 60° C.

8) Soluble in hot or cold 95% ethanol.

9) Soluble in 95% ethanol plus 16% water in the cold when the solution clouds, but clears again when heating to 60° C.

10) Soluble in hot or cold 90% methanol.

11) Soluble in cold methanol to which up to 13% water has been added and which clouds, but clears on heating to 60° C.

Analytical Procedure: In order to make a qualitative determination of hydroxy fatty acid soaps in greases, the following methods were found to be effective:

Method A: Take a 50-gram sample of grease, add 50 grams of heptanes or a petroleum fraction with a boiling range between 75° C. to 100° C., mix and heat until a smooth dispersion results. Add 100 ml. of 1:3 HCl (C.P.). Heat and agitate to regenerate the fatty acids. Note whether any scum or curd is formed. Hydroxystearic acid is insoluble in petroleum ether or heptanes and usually sep...tes out. Transfer to separatory funnel, drain off mineral acid layer and wash petroleum ether or heptanes layer with three (3)

This contribution is published as a "pioneer" article with the recognition that repeatability and reproducibility have not been established, and mention of data by other comparable techniques is lacking. It is the expressed hope of the authors that this article may stimulate further interest among those concerned in this field.

by M. P. Benitez and H. A. Levey
International Lubricant Corporation

25 ml. portions of distilled water or until free of mineral acid. The insoluble hydroxystearic acid is washed with two (2) 25 ml. portions of petroleum ether or heptanes, is dried and a melting point and an acetyl value is determined.

Method B: A 50-gram sample of the grease is dissolved in 75 ml. of petroleum ether and is heated until a smooth dispersion results. Add 100 ml. of 1:3 HCl (C.P.). Heat and agitate to regenerate the fatty acids. Transfer to a separatory funnel, drain off mineral acid layer and wash petroleum ether layer until free of mineral acid (three 25 ml. portions of distilled water are usually sufficient). Add phenolphthalein indicator to petroleum ether layer and saponify with 20 ml. of alcoholic sodium hydroxide solution (10%). Place in separatory funnel and allow the two layers to separate. Drain off the alcohol layer, wash the petroleum ether layer three times with 25 ml. portions of 50% ethanol (neutralized to a slight pink color with sodium hydroxide solution), and combine these washings with the alcohol layer. Wash alcohol layer with two (2) 25 ml. portions of petroleum ether or heptanes and discard these washings. Evaporate most of the alcohol by boiling over a water bath to a very low volume. Regenerate the fatty acids with 1:3 HCl (C.P.) solution. Add 50 grams of heptanes (boiling range, 75° C. 100° C.), transfer to separatory funnel, drain off mineral acid layer. Wash petroleum ether layer until free from mineral acid (usually three 25 ml. portions of distilled water are sufficient). Hydroxystearic acid is insoluble in heptanes (petroleum ether) and usually separates out. The insoluble hydroxystearic acid is washed with two (2) 25 ml. portions of petroleum ether, is dried and melting point and an acetyl value are determined.

A)—Melting Point: This may be determined by the capillary tube method in the usual way using either water or glycerol as bath.

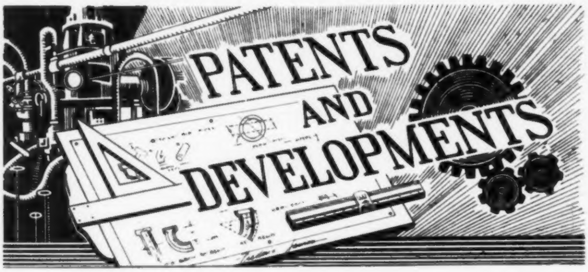
B)—Acetyl Value: A sample of the hydroxystearic acid is refluxed with an excess of acetic anhydride for about 2 hours, allowed to cool and transferred to a beaker. Water is then added and the beaker is placed on a hot plate and the contents are heated to boiling for about one-half hour. A stream of CO_2 is bubbled through the mixture to prevent bumping during the process. The water is siphoned off and more water is added and the mixture is again heated to boiling. This is repeated until the aqueous layer is neutral to litmus. A known weight of the acetylated product is saponified with a known amount of alcoholic potassium hydroxide, and when saponification is completed, the alcohol is evaporated off. The soap is dissolved in water. A known amount of standard sulfuric acid equal to the amount of alcoholic potassium hydroxide added is used. The regenerated fatty acid is filtered off and washed with boiling water until the washings are no longer acid. The combined filtrate and washings are titrated with standard potassium hydroxide using phenolphthalein as an indicator.

Calculation:

$$\text{Acetyl Value} = \frac{\text{Ml. of standard KOH} \times 5.61}{\text{Weight of acetylated product}}$$

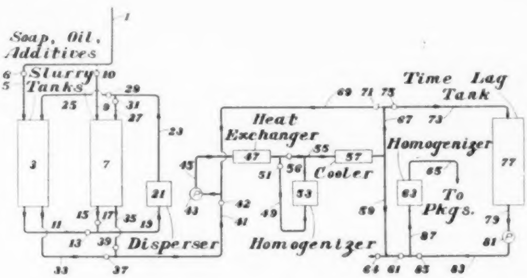
The above determinations obtained by two different approaches establish the presence of hydroxystearic acids; viz. first, by different solubilities, and second, the determination of the acetyl value indicating the presence of, and the amount of, hydroxy fatty acids. It is recognized that hydroxy-acids from natural sources, used in industrial greases, invariably have the hydroxyl group in the 12 position.

It is obvious that it is basically necessary to first separate and purify the hydroxy fatty acids, as it is wholly impracticable to run the acetyl number on the finished grease in view of side reactions and other conditions which would seriously falsify such results as may be obtained.



CONTINUOUS OR SEMI-CONTINUOUS GREASE PRODUCTION

On the basis that none of the present continuous grease-making methods are suitable for making soda, lime or soda-lime base greases, a Pure Oil Co. patent (U.S. 2,542,159) discloses the method, the flowsheet of which is shown in the cut.



Soap, mineral oil and additives are fed in proportioned amounts to either slurry tank 3 through line 5, or slurry tank 7. Discharge lines 11 and 15 are led to the inlet of disperser or homogenizer 21, which is preferably a Cornell mixer or Kombinator. As is apparent from the cut, the mixture of ingredients can be circulated from either slurry tank through the homogenizer in order to prepare a good suspension.

The mixture then may be pumped by pump 43 into heat exchanger 47, such as a Votator, and thence into a second homogenizer 53 where complete dispersion of the soap in the oil is obtained under extremely high-conditions of shear. The grease is then passed through heat exchanger 57 (Votator) where it is cooled down to a desired temperature for processing.

After leaving heat exchanger 57, the grease is fed into a third homogenizer 63, and the finished grease is then packaged through line 65. Time lag tank 77 is provided, and is of sufficient size to permit the mixture to move continuously through it as it is circulated through line 59 or passed through homogenizer 63.

In making the grease, sodium, calcium, aluminum, lithium, sodium-calcium, sodium-aluminum and other metal base greases may be used. The soap may be made from fat, oil or fatty acid. In addition to common lard or tallow, other suitable fats and oils which may be used are bone fat, castor oil, corn oil, cottonseed oil, horse fat and wool fat. Various fatty acids having from approximately 15 to 24 carbon atoms per molecule, such as oleic acid, stearic acid, animal fatty acids, cottonseed fatty acids, as well as petroleum naphthenic acids and acids obtained from oxidation of paraffin waxes may be used. Whether or not the fatty acid or the fat or oil is used will depend on whether it is desired to have glycerin present in the final product. Various additives for imparting particular characteristics to the grease may also be added. Fillers such as graphite, asbestos and sulfur may be blended into the mixture fed to the slurry tanks. Where it is desired to produce a grease with stringiness, high molecular weight polyisobutylene polymers or natural or synthetic rubber may be added in small amounts. Anti-oxidants such as phenol, naphthylamine, amino phenols and others may be added in small amounts. Extreme pressure addition agents such as sulfurized fatty oils, sulfurized and phosphorized fatty oil, sulfochlorinated organic compounds and thiophosphoric acid organic compounds may be added.

The processing of the grease mixture from the pump 43 through the remainder of the apparatus depends on the nature of the grease. Soaps when subjected to heat, exhibit three transitional temperatures, known as the uni-dimensional, bi-dimensional and tri-dimensional melting points. The bi-dimensional melting point is also known as the plasticity point and the tri-dimensional melting point is also known as the complete melting point. The transitional temperatures depend on the nature of the soap. For example, in the case of sodium stearate, these temperatures are approximately 164°F. for the uni-dimensional melting point; 266°F. for the bi-dimensional melting point; and 374°F. for the tri-dimensional melting point. The transition points become correspondingly lower as the unsaturation of the fat, oil or acid employed in making the soap increases. Since the fats, oils or acids used in making soap for the manufacture of grease are essentially mixtures of stearin and olein or of stearic and oleic acid, the transitional points of the soap will be somewhat lower than those given above for sodium stearate.

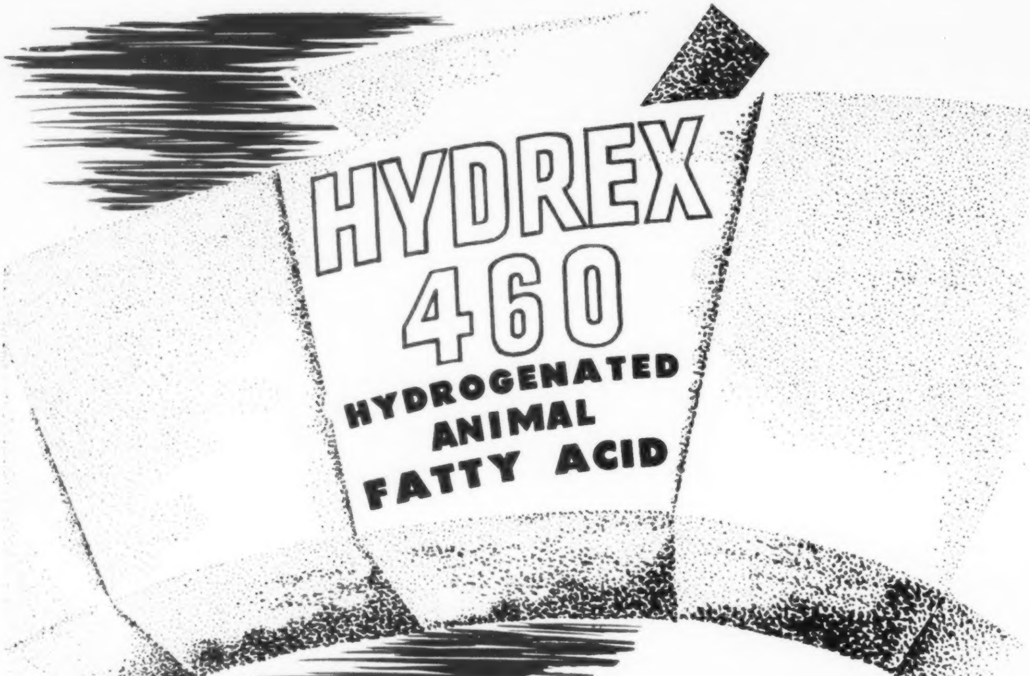
It has been discovered that if the soap-oil mixture is subjected to homogenized action at/or slightly above its bi-dimensional melting point, but below the tri-dimensional melting point of the soap, a grease of excellent texture and appearance can be made in a continuous operation.

In Votator 47, the temperature of the dispersion is raised to 220° - 290° for a soda base grease, or 275° - 310° for an aluminum base grease, while in Votator 57, the temperature of the grease is reduced to about 150° - 200° F. for a fibrous grease, or 75° - 125° F. for a smooth sodium soap grease.

TREATING BLACK GREASE

In order to produce a new and more esterified product from a black grease or acidulated soap stock, Trendex Co., in its U. S. Patent 2,547,014, proposes to heat the black grease to cause esterification of diglycerides, etc., remove water, then add nickel catalyst and hydrogenate the mixture. The water must be removed or else hydrogenation will not be effected.

In practice, the black grease, rich in fatty acids, is placed in a pressure vessel and hydrogen is admitted to about 10 psi. Then the bomb is heated to 360°F. for about two hours. Water is liberated as steam and is released through a blow-off valve with some hydrogen. Then 0.3% nickel catalyst is introduced into the hot esterified grease and the mixture is heated with hydrogen at 50 - 100 psi to 340° - 425°F. until



FOR "LOCKED-IN" STABILITY

Our hydrogenation process makes it possible in regular production runs to reduce the proportion of unsaturated compounds to a minimum . . . greatly improving the stability of the fatty acid *and the end product.*

For example, Hydrex 460 Hydrogenated Animal Fatty Acid is a water-white, stable, saturated fatty acid that is relatively rich in stearic acid (about 70.0%), with about 30% palmitic acid and practically free of oleic acid. Yes, with our hydrogenation technique, we are producing high melting point, low iodine value fatty acids with controlled composition. Manufacturers of fatty acid esters, metallic stearates, special lubricants and other products where *stability* is essential, should investigate medium-priced Hydrex 460 Hydrogenated Animal Fatty Acid.

HYDREX 460 SPECIFICATIONS

Titre	(134.6-140.0°F) 57.0-60.0°C
Color 5¼" Lovibond Column (max)	4 Yellow-0.4 Red
Iodine Value (Wijs)	1-4
Free Fatty Acid (as oleic)	100-103%
Acid Number	199-205
Saponification Value	201-207

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the desired hydrogenation is effected. A more stable, lighter-colored product is recovered.

SODIUM MYRISTATE GREASES

According to a Texas Company patent (U.S. 2,542,570), it has been found that sodium myristate greases possess certain characteristics which render them of particular value for high temperature lubrication of anti-friction bearings. Besides possessing a dropping point in excess of 400°F., they are also resistant to the leaching effect of water and provide satisfactory lubrication with negligible texture or phase change even at temperatures above 300°F. Such characteristics are particularly unusual for sodium base greases of the same consistency and yield.

OLEFIN POLYMER LUBRICANTS

While there are many factors which affect the interaction of an oil and a given soap, most of the physical constants which measure these factors do not correlate with the observed behavior of the properties of the grease. Viscosity index, specific dispersion, refractive index, and density of an oil are very poor indicators of the behavior of soap and oil when they have been heated sufficiently to cause mutual solubility, cooled suddenly to form a gel, and worked to a smooth grease. While the above-mentioned physical properties do have an influence, it has been found that viscosity has a considerably greater influence than do the others. Sodium stearate may, for example, be dispersed readily in petroleum oil fractions having a viscosity of less than approximately 400 Saybolt Universal seconds at 100 F. but may be only slightly dispersed in petroleum oil fractions having appreciably higher viscosities. Lithium stearate, on the other hand, appears to be dispersable in practically all oils, whereas lithium laurate appears to be limited, as regards satisfactory dispersion, to oils having viscosities not greater than 532 Saybolt at 100° F. In order that a grease may be obtained from an oil and a soap, the soap must have a solubility in the oil within certain limits. If the soap is insufficiently soluble, no grease is formed, but instead, a suspension of solid soap in oil is obtained. If the soap is too soluble, a liquid solution of soap in oil is obtained. Thus a certain range of partial solubility is necessary.

In its U.S. patent 2,526,986, Phillips Petroleum Co. discusses the preparation of polymer oil greases of high consistency and work stability. Aliphatic monomers are better utilized as dispersion media for metal salts of fatty acids for grease formation than petroleum lubricating oil fractions. It is preferred to use polymers having viscosities of 35-500 Saybolt Universal at 100°F.

Among the suitable polymers are those obtained by treating propylene with zirconium tetra-chloride, as well as C4 and C5 olefins polymerized with tetrahalides of group IV elements (particularly those having atomic numbers between 14 and 50). Fatty acid soaps of sodium, lithium, calcium and aluminum give the best products.

One suitable oil in the SAE 10-30 range, obtained from propylene, had the following properties:

Gravity, API	36.9
Refractive index	1.4666
Specific dispersion	107.8
Viscosity, SUS at 100°F.	457.1
Viscosity, SUS at 210°F.	54.5

PATENTS

U.S. 2,546,585 (Electro-Hydraulics, Ltd.) — Hand actuated grease pump.

U.S. 2,546,672 (Tecalemit Ltd.) — Nipple or lubricant-receiving device.

U.S. 2,546,671 (Tecalemit Ltd.) — Nipple fitting.

GREASONALITIES

W. W. Fischer

HARDESTY NAMES FISCHER

Hardesty & Company, 60 East 42nd Street, New York, has appointed Mr. W. W. Fischer sales manager of the concern. Mr. Fischer has been associated with Mr. W. C. Hardesty for a good many years.

A modern plant, located in Philadelphia, Pennsylvania, for production of stearic acid, red oil, glycerine and various fatty acids, has just been completed, and the company is rapidly expanding.

DEEP ROCK APPOINTS PRESIDENTIAL ASSISTANT

Richard K. Huey, who has been vice president in charge of Deep Rock Oil Corporation's production division, has been named assistant to the president, and is succeeded by Carl A. Houy, who has been general superintendent since March, 1950, President W. H. Garbade has announced. In this new capacity, Mr. Huey will work on special assignments involving producing properties.

Mr. Huey started in the utilities business nearly 35 years ago, but came to Oklahoma and switched to oil in 1915, then joined Deep Rock in 1920. He is credited with pioneering the use of electricity for drilling and pumping, and with the early installation of modern pumping units in Oklahoma oil fields.

Mr. Houy, a native of Texas, attended Schreiner Institute and the University of Texas before he began as a roughneck with Humble in Texas fields 14 years ago. In 1940, he transferred to Republic Natural Gas Company at Dallas as engineer and steadily progressed until he was vice president of the gas division and had charge of all the company's engineering and drilling at the time he joined Deep Rock in 1950. He is a member of the American Petroleum Institute, Independent Petroleum Association of America and the Independent Natural Gas Association. He resides in Tulsa with Mrs. Houy and two children.

THREE NEW MEMBERS JOIN FOOTE MINERAL RESEARCH STAFF

Charles Wiley, Research Chemist, has joined Foote's Research and Development staff following completion of graduate work in physical chemistry at McGill University at Montreal. Prior to that time he had taken an M.S. Degree in Organic Chemistry at the University of Massachusetts in 1949 and a B.S. in Chemistry at the University of Pennsylvania in 1947.

G. Arthur Brown, Jr., now takes up his new position as Mineralogist on Foote's Research staff. Before going to his new post, Brown was on the teaching staff at the University of Michigan where he took his B.S. in Mineralogy last year.

Peter F. Mento, Jr., Foote's new research Chemical Engineer, takes up his new job after a year with the Philadelphia Branch, Quartermaster Corps. Prior to that he had been with the DuPont Company in their research and development division. Mento took his M.S. at the University of Delaware in 1949, and a B.S. in Chemical Engineering at Villanova in 1944.

Vernon W. Colby

EMERY INDUSTRIES PROMOTES COLBY

Emery Industries, Inc. announces the promotion of Vernon W. Colby to Assistant Chemical Sales Manager supplementing the activities of Robert T. Hull, also an Assistant Chemical Sales Manager, and Robert F. Brown, Chemical Sales Manager.

Mr. Colby received a Bachelor of Science degree in textile chemistry from the Lowell Textile Institute. After several years as a dyer and following a tour of duty with the armed forces, he became associated with Emery Industries in a sales capacity. Prior to his recent appointment, Mr. Colby has been servicing the territory composed of Connecticut, Rhode Island, and Eastern New York State.

NOPCO ANNOUNCES THE TRANSFER OF JOHN J. RYAN TO NEW PACIFIC DIVISION

John J. Ryan has been transferred to the sales force of the newly-formed Pacific Division of the Nopco Chemical Company. Announcement of this transfer, which is effective May 1, was made by G. D. Davis, Vice-President in charge of Sales, from the Nopco home offices at Harrison, New Jersey.

Prior to his new appointment, Mr. Ryan was sales representative for the company in the New York-Pennsylvania area. A graduate of North Carolina State College, he has been affiliated with Nopco since 1946. In the Pacific territory he will continue handling the company's broad line of chemical specialties for such processing industries as pulp and paper, tanning, metalworking, textile and yeast manufacture. In addition to the Nopco products he will also handle the sales of metallic soaps produced by the Metasap Chemical Company, a wholly owned subsidiary. The Metasap products, which are used extensively in greasemaking; paint, varnish, and lacquer; and in the plastics industries, as well as the Nopco line of surface active chemicals, are now being produced at the company's recently opened plant at Richmond, California.

George R. Zust, former Assistant Manager of the company's Textile Specialties Division, will replace Mr. Ryan in the New York-Pennsylvania area.

WITCO NAMES DAMEN WASHINGTON MANAGER

Clement A. Damen has been appointed manager of Witco Chemical Company's Washington office, located at 1111 Seventeenth Street N. W., Washington 6, D. C.

As Washington representative of Witco's Defense Products Division, Mr. Damen will serve as contact for the sales and manufacturing divisions.

Mr. Damen has been connected with the Witco sales organization for twenty-five years and, at one time, was manager of the Boston office.

MIDWEST RESEARCH INSTITUTE APPOINTS ASSOCIATE RESEARCH DIRECTORS

As a result of a considerable expansion in the research volume at Midwest Research Institute, and as part of a long-term plan of growth, Dr. C. N. Kimball, president, has announced the appointment of Dr. M. H. Thornton, chairman of the Institute chemistry division, and Martin Goland, chairman of the engineering division, as associate research directors of the Institute.

Kimball explained that the Institute will now operate around four broad research divisions in the fields of physics, chemistry, chemical engineering, and engineering sciences.

Dr. R. R. Hancox is chairman of the physics division. Dr. W. S. Gillam, Senior Chemist at the Institute, will become chairman of the chemistry division, and William Niven, Senior Chemical Engineer, will serve as chairman of the chemical engineering division.

A nationally known authority in agricultural and industrial chemistry, Dr. Thornton will become associate director for chemistry, coordinating activities in this field at the Institute, where he has been a staff member since 1946. During that interval he has directed work on many problems involving research and practical application in the fields of organic, physical, industrial and bio-chemistry. He is a member of the American Chemical Society, the American Oil Chemists' Society, and the American Section of the Society of Chemical Industry.

Goland, who will be associate director for engineering sciences, is widely recognized in the field of applied mechanics. He came to the Institute in 1946 from the research laboratories of Curtiss-Wright corporation, where he was in charge of its structures department. His professional work has included research and development on programs involving structural aerodynamics and design aspects of combat aircraft, guidance and stability designs of guided missiles, vibration and flutter problems, and many industrial mechanical design applications. He is editor of the internationally-known engineering publication, "Applied Mechanics Reviews", is a member of many technical societies, and serves on the Vibration and Flutter sub-committee of the National Advisory Committee for Aeronautics.

Gillam received his Ph.D. degree from the University of Nebraska in 1938 and has been at the Institute for six years. Previously he held the post of professor at Purdue University, Michigan State College, Nebraska Wesleyan University, and the University of Nebraska.

Niven received his master's degree from Montana State College in 1946. He has been at the Institute since that time, with previous experience on the Montana State College faculty and as a chemical engineer with the U. S. Army, Corps of Engineers.

SOUTHWEST GREASE & OIL ANNOUNCES PERSONNEL APPOINTMENTS

Mr. Lindsley K. Norton has recently been appointed Office Manager and Controller of the Southwest Grease & Oil Company, Inc., in Wichita, Kansas. This appointment became effective April 1, 1951. At the same time, Mr. A. G. (Andy) Keleher became Laboratory Processing Engineer. Mr. Harden B. Elliott has taken the position of Plant Co-Ordinator. Mr. Elliott, former Sales Representative in Missouri, Iowa, Illinois and Wisconsin, will be succeeded in these territories by Mr. M. L. Hendricks, on an enlarged territory assignment.

★ 1951 - FUTURE MEETINGS OF YOUR INDUSTRY ★

JUNE, 1951

18-22 American Socy. for Testing Materials (annual meeting), Chalfonte-Haddon Hall, Atlantic City, N. J.

AUGUST, 1951

13-15 Socy. of Automotive Engineers, Inc. (west coast meeting), Olympic Hotel, Seattle, Wash.

SEPTEMBER, 1951

3-7 American Chemical Society (120th national Diamond Jubilee meeting), Hotel Statler, New York, N. Y.

5-8 Oil Industry Information Committee, Waldorf - Astoria Hotel, New York, N. Y.

6-7 Michigan Petroleum Assn. (annual fall convention), Ramona Park Hotel, Harbor Springs, Mich.

8-9 International Union of Pure and Applied Chemistry (16th conference), Hotel Statler, New York, N. Y.

10-13 International Congress of Pure & Applied Chemistry (12th conference), Hotel Statler, New York, N. Y.

11-13 Socy. of Automotive Engineers, Inc. (tractor meeting), Hotel Schroeder, Milwaukee, Wisc.

12-13 A.P.I. Lubrication Committee, Atlantic City, New Jersey.

12-14 National Petroleum Assn., Hotel Traymore, Atlantic City, N. J.

14-15 International Union of Pure and Applied Chemistry (16th conference), Hotel Statler, Washington, D. C.

24-26 Independent Oil Compounders Assn., (4th annual meeting), Hotel Detroit-Leland, Detroit, Michigan.

25-28 The American Socy. of Mechanical Engineers (fall meeting), Radisson Hotel, Minneapolis, Minn.

OCTOBER, 1951

8-10 The American Oil Chemists' Socy. (fall meeting), Edgewater Beach Hotel, Chicago, Ill.

8-12 National Safety Council (39th national safety congress and exposition), Stevens Hotel, Chicago, Ill.

13-14 Indiana Independent Petroleum Assn. (fall convention), Hotel Severin, Indianapolis, Ind.

14-20 Oil Progress Week.

29-31 N.L.G.I. (annual meeting), Edgewater Beach Hotel, Chicago, Ill.

NOVEMBER, 1951

3-8 Oil Industry Information Committee, Stevens Hotel, Chicago, Ill.

5-8 American Petroleum Institute (31st annual meeting), Palmer House, Chicago, Ill.

5-8 A. P. I. Lubrication Committee, Chicago, Illinois.

25-30 The American Society of Mechanical Engineers (annual meeting), Chalfonte-Haddon Hall, Atlantic City, N. J.

26 to Dec. 1 23rd Exposition of Chemical Industries, Grand Central Palace, New York, N. Y.

DECEMBER, 1951

2-5 American Inst. of Chemical Engineers (annual meeting), Chalfonte-Haddon Hall, Atlantic City, N. J.

3-4 Chemical Specialties Mfrs. Assn. (38th annual meeting), The Mayflower, Washington, D. C.

★

APRIL, 1952

7-9 American Society of Lubrication Engineers (7th annual meeting and lubrication show), Hotel Statler, Cleveland, Ohio.

JUNE, 1952

9-10 Chemical Specialties Mfrs. Assn. (38th mid-year meeting), Hotel Statler, Detroit, Mich.

23-27 American Socy. for Testing Materials (annual meeting), Hotel Statler, New York, N. Y.

OCTOBER, 1952

20-24 National Safety Council (40th national safety congress and exposition), Stevens Hotel, Chicago, Ill.

NOVEMBER, 1952

30 to Dec. 5 American Socy. of Mechanical Engineers, New York, N. Y.

DECEMBER, 1952

1-6 20th National Exposition of Power & Mechanical Engineering, Grand Central Palace, New York, N. Y.

8-9 Chemical Specialties Mfrs. Assn. (39th annual meeting), Hotel New Yorker, New York, N. Y.

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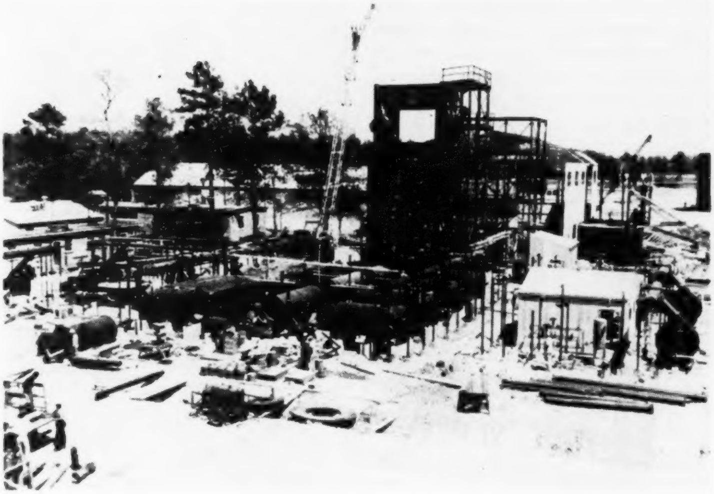
NEWS About Your Industry



NEW CARBON BLACK PLANT TAKES SHAPE

The new $2,000,000 Continental Oil Black Company plant for the production of high abrasion furnace black from oil, begins to take shape at Westlake, near Lake Charles, Louisiana. The new plant with an annual capacity of 25,000,000 pounds, is a joint enterprise of Continental Carbon Company and Continental Oil Company. Rise in the use of synthetic rubbers, especially "cold rubber", has increased substantially the demand for high abrasion furnace black. It is anticipated that the plant will be in production in June of this year. Output of the new plant will be distributed by Witco Chemical Company.

LUBRICATE FOR SAFETY EVERY 1000 MILES

AN INVITATION TO IDEAS

To encourage progress, The SINCLAIR PLAN will open the doors of the company's great petroleum laboratories to the best ideas of inventors everywhere for better petroleum products.

Inventive Americans are often hamstrung today. Not because of any lack of ideas, but because of a need for large and expensive facilities to find out if and how their ideas work.

This was no obstacle in our earlier days. With nothing but his own hands and a few dollars, Henry Ford proved to the world that he could build a gasoline automobile that ran. Eli Whitney built his cotton gin in a barnyard with homemade tools—and it worked.

Contrast this with the fact that the first pair of nylon stockings took ten years of research time, enormous laboratory facilities, and $70,000,000.

Today, science and invention have become so complex that a man with an idea for a better product often needs the assistance of an army of specialists and millions worth of equipment to prove his idea has commercial value.

Within the petroleum field, The Sinclair Plan now offers to provide that assistance—in the interest of both the inventors and ourselves, and of the millions who buy Sinclair products.

THE SINCLAIR PLAN

Under this Plan, Sinclair is opening up its great research and development laboratories at Harvey, Illinois, to independent inventors, wherever they may be, who have sufficiently good ideas for better petroleum products.

Sinclair Research Laboratories have nine modern buildings equipped to handle every phase of petroleum research. These laboratories were built with an eye to the future, and their potential capacity is larger than is required for current work. This capacity will be made available for developing the best ideas of outside inventors.

If you have an idea for a better petroleum product or for a new application of a petroleum product, you are invited to submit it to the Sinclair Research Laboratories, with the provision that each idea must first be protected, in your own interest, by a patent application or a patent.

If the directors of the laboratories select your idea for development, they will make, in most cases, a very simple deal with you: In return for the laboratories' investment of time, facilities, money and personnel, Sinclair will receive the privilege of using the idea free from royalties. This in no way hinders the inventor from selling his idea to other companies or from making any kind of arrangements he wishes without further reference to Sinclair.

HOW TO PARTICIPATE

Instructions on how and where to submit ideas under The Sinclair Plan are contained in a complete Inventor's Booklet that is available on request. Write to the office of the Executive Vice-President, Sinclair Research Laboratories, Inc., 630 Fifth Avenue, New York 20, N. Y., for your copy of this booklet. *Important*: Please do not send in any ideas until you have sent for and received the booklet of instructions.

FOOTE MINERAL COMPANY EXPANSION TO DOUBLE REFINED LITHIUM ORE OUTPUT

Foote Mineral Company's new $214,800 expansion program to enlarge existing facilities at their Exton, Pa., plant will be used primarily to double the company's production of lithium in the primary refining stage. Need for the additional plant and equipment is dictated by a new Foote-discovered process, developed in answer to growing demand for lithium of all types. The new facilities will process lithium bearing ores mined at Foote's newly acquired source at Kings Mountain, North Carolina. Gordon H. Chambers, Vice President, stated that new construction will start late this month, with actual production scheduled for early fall.

Foote's new mining activity at Kings Mountain is the realization of planning and studies begun in 1937. The tract covers 881 acres and gives Foote control of the largest known, all weather source of lithium in the western hemisphere. Exploration, which included 6350 feet of diamond drilling, has proved the presence of vast quantities of lithium bearing ores—sufficient for many years' operations.

Market diversification coupled with Foote's 103 products put their sales close to $5,500,000 during 1950, an increase of 50% over 1949. Now in their 75th year, Foote Mineral Company's volume has grown soundly and steadily from the $394,455 mark in 1936. Research and development have been prime factors in the company's growth. Proof of their efforts in these fields is today's widespread use of lithium and its compounds throughout the ceramic, welding, petroleum and electronics industries. Always searching for new uses for their products, Foote researchers are currently working on a new household bleach in the form of a powdered compound of lithium hypochlorite.

LUBRICATE FOR SAFETY EVERY 1,000 MILES

STEWART-WARNER INTRODUCES THE "MOTOR MINDER"

Introduction to the passenger car public of a new instrument — the "Motor Minder" — which enables the driver to operate his automobile engine at peak efficiency and at the same time drastically reduce gasoline consumption, has been announced by the Instrument Division of Stewart-Warner Corporation.

This accurate instrument, operating on the principle of the vacuum gauge, can be read by the driver at a glance, according to E. N. Robinson, sales manager of the Instrument Division.

Divided into five different colored segments, the dial of the Motor Minder shows:

1. When gasoline is being wasted.
2. When the engine is operating most efficiently.
3. When carburetor is out of adjustment.
4. When ignition timing is bad.
5. When valves are sticking, piston rings are leaking or when other engine ills exist.

The Motor Minder offers the car owner a type of instrument that has long been recognized as a "must" in the operation of aircraft, speedboats, racing cars, etc., where the driver or operator cannot rely simply on "feel" or sound but must have instruments which will warn of malfunctioning and will insure proper engine operation at all times.

A competent mechanic, Robinson pointed out, always employs a vacuum gauge when a car is brought in for diagnosis and tune-up. With the Motor Minder permanently installed in a car, the owner is similarly able to detect and correct minor ills before they develop into major repair bills. This is particularly significant in today's crowded service market, Robinson asserted, and will be more so if the supply of trained mechanics is further drained off by the armed services, as it was during World War II.

Motorists have found amazing fuel economies—as much as four gallons of gasoline per tankful—by driving with the Motor Minder. Over-acceleration, which causes useless waste of gasoline, is now easily avoided, and unnecessary strain on the engine, as well as gasoline wastage, can be eliminated by a glance at the Motor Minder to determine when to shift to low, second or high gear in ascending or descending hills.

The Motor Minder can be easily installed on any car in a few minutes. It can be mounted on the steering post, atop the instrument panel, under the panel or in the panel. It is being distributed through Stewart-Warner Instrument Division distributors and is available to car owners through car dealers, accessory stores and other automotive equipment and supply outlets.

CITATION OF MERIT TO SERVICE STATION OPERATORS

New York—Operators of America's 200,000 service stations received a Citation of Merit from The American Weekly. The award was made concurrently with publication in the May 20 issue of the Weekly of a story entitled "Heroes of the Gas Pump". This relates a number of instances where service station men risked their lives to help neighbors or passing motorists.

The Citation of Merit, signed by publisher William Randolph Hearst, Jr., for the American Weekly reads:

"Whereas: The people of this nation in their daily travels to and from work or to and from places of recreation and relaxation will find service at this station far beyond the call of duty.

"Whereas: Under this sign, the traveling public finds dependability, information as to directions, road conditions, maps, advice and comfort,

"Whereas: This station is ready to serve the traveling public in emergencies, in peril and even in rescue work,

"Let It Be Known: That the man who runs this station has risked his capital in an opportunity that only America offers—a freedom to compete in a business of his choice.

"He stands ready to serve you in fair weather and foul.

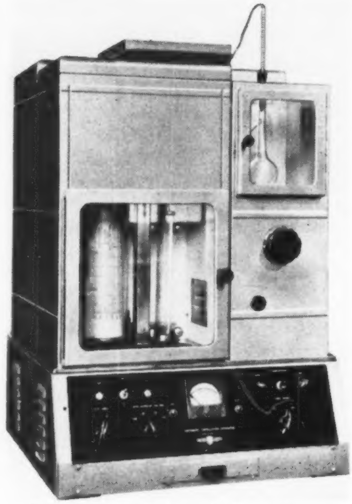
"He is a respected member of his community. He contributes to its welfare in a score of ways.

"His hours are long and arduous—his work is hard.

"He stands ready to serve you in emergencies, as well as to fill your tank.

"He is your weather prophet, your guide, your direction book and your counsellor on the best routes. He can direct you to churches, movies or ball games. Above all, he is a business man —and a good one.

"He deserves, but never demands, your respect. Give it to him freely."



On the Precision-Shell Automatic Distillation Apparatus temperature and volume are plotted continuously; time is recorded every two minutes.

PRECISION-SHELL AUTOMATIC DISTILLATION APPARATUS

Laboratory managers have long awaited an automatic apparatus which would release personnel from the tedious, costly testing procedure incurred with routine distillations. Precision Scientific Company, in cooperation with the Shell Development Company, announces the completion of an Automatic Distillation Apparatus.

The instrument will perform the following ASTM tests:

D86, Distillation of Gasoline, Naphtha, Kerosene and Similar Petroleum Products; D 268, Sampling and Testing of Lacquer Solvents and Diluents; D 1078, Distillation Range of Lacquer Solvents and Diluents; D 447, Distillation of Plant Spray Oils. With a slight modification, the instrument can be used for D 216, Distillation of Natural Gasolines. It is also applicable for the organic chemistry industries and has wide use in any college, testing or industrial control laboratory.

The Distillation Apparatus has the following features which release the operator from time-consuming chores, besides eliminating the human error factor:

The temperature is plotted continuously; volume is plotted continuously; the time is recorded every two minutes; heating (distillation) rate is controlled electronically; distillation rate can be varied from 4.5 cc. per minute to 9.0 cc. per minute.

The instrument is essentially simple to operate. After the sample flask is in place, one adjustment is made to obtain proper initial heat and distillation rate, and a line switch is turned on. There are no other operational steps except the removal of a continuously recorded chart. Dimensions of the new apparatus conform with the standards already specified by ASTM committees for distillation tests. Everything needed for operation is enclosed within stainless steel walls. Controls are mounted on one panel directly in front of the operator.

SUNLAND REFINING RECEIVES CERTIFICATE OF EXCELLENCE

Sunland Refining Corporation has just been notified that it has been awarded the Certificate of Excellence for maintenance practices excelling national standards established by Commercial Car Journal's Board of Experts. Sunland is the only oil company in the West and one of four oil companies in the United States to receive this recognition, and only nine other fleets in California received the same recognition.

Mr. James M. Scott, Superintendent of Automotive Equipment and Plant Maintenance for Sunland Refining Corporation, has also received notice from A. W. Green, Managing Editor of Commercial Car Journal, of his appointment as a member of the Journal's Board of Experts. During the past year, this Board of Experts collaborated in developing high fleet maintenance standards and during the past couple of years, Mr. Scott has been serving on a panel studying the life expectancy of principal parts and components of commercial vehicles, during which time life expectancy data on 138 different principal parts and components of commercial vehicles were developed, which is the first time that this type of information has been compiled.

Mr. G. A. Olsen, President of Sunland Refining Corporation, is also a Director of the N.L.G.I.

STANDARD OIL OF N. J. LAUDED BY HARPER'S

The system of governance of Standard Oil Company (New Jersey), America's largest industrial corporation, is a striking example of cooperative effort at the highest level, according to the current (June) issue of Harper's magazine.

In an article describing the far-flung Standard empire, its president, and the management of its operations, Harper's declares that plainly a Napoleonic personality installed in the presidency could reduce the system to chaos in short order.

Instead of a dictator type management, Jersey Standard, itself a holding company presiding over myriad operating subsidiaries, is ruled by a board of directors, or "a board of professional managers," and a president, who coordinates their activities. Each of the fourteen directors is a specialist in certain aspects of the overall operations, and duties and responsibilities are divided along functional as well as area lines. Full responsibility for directing the affairs of the operating companies is delegated to their chief executives, and the parent company performs advisory and supervisory functions only in relation to the whole empire.

This system of management and the successful way in which it operates, says Harper's, tell us a lot about the talents of Eugene Holman, Standard president, and the delicate balance which he maintains in the giant corporation.

"And it tells us a lot about the era in which we live that the oil empire over which he presides should be run in this way—not by men of the stock-market-trader type, or of the bargaining type, such as were likely to come to the top in the late nineteenth century; not by banker-minded specialists in financing such as tended to be dominant in the early twentieth century; not by super-salesmen such as flourished in the nineteen-twenties; but by a team of expert oil technologists skilled in management, with a geologist turned manager-of-managers at the very top of the heap."

"People who cultivate preconceptions about how men in big jobs should look and act are no doubt somewhat dashed on meeting Eugene Holman," says the article. "He neither looks nor acts up to anybody's preconception of his part. . . . A million miles from that ogre of the British Laborites, the 'hard-faced American capitalist,' Holman's visage is mild, kindly, fairly certain to mellow into benignity in due course."

While Jersey Standard is a holding company, it is entirely different from the popular image of such a concern, it is pointed out. Least of all is it an example of the most unpopular kind of holding company, the kind which is organized for the financial exploitation of the operating companies regardless of their, and the public, interest.

"Jersey Standard is a holding company that, while not for a moment losing sight of the need for profits, broadens its interest beyond the mere scanning of balance sheets to include advisory and supervisory relations with each unit of its holdings," according to the article.

And, as the company also sets forth in its manual, "No business exists in economic isolation. It is part of the economic and social environment of its time. Its policies and actions affect many segments of that environment—and in turn are affected by them."

INTERNATIONAL LUBRICANT CORPORATION

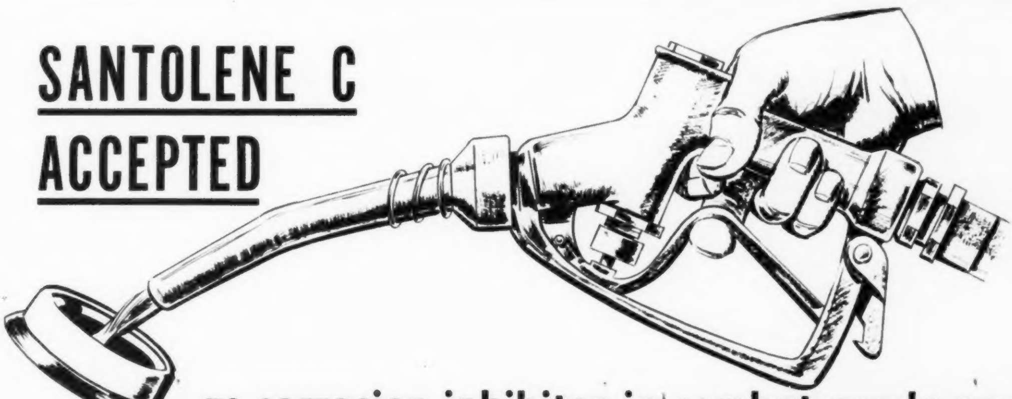
New Orleans, U. S. A.

MANUFACTURERS
OF
QUALITY
LUBRICANTS

AVIATION
INDUSTRIAL
AUTOMOTIVE
MARINE

With Research Comes Quality, With Quality Comes Leadership.

SANTOLENE C ACCEPTED



as corrosion inhibitor in combat-grade gasoline

Monsanto Santolene C has been accepted as a corrosion inhibitor—at the option of the supplier—for combat-grade gasoline by the Ordnance Department under specification MIL-G-3056. Write today for details on how you can use Santolene C to add rust-preventive properties to your gasoline, Diesel fuel, kerosene and fuel oil . . . how you can employ Santolene C to control corrosion in tanks, lines and equipment handling any light petroleum product.

The effectiveness of Santolene C has been proved in the laboratory and in the field. These findings have been confirmed by a major oil company which has marketed Santolene C in all types of light petroleum products for more than a year.

Santolene C is product-soluble. It burns completely with the fuel, leaving no residues whatever. Diesel and gasoline engine tests have demonstrated that Santolene C has no effect on engine cleanliness, injector fouling or any other factor of engine performance.

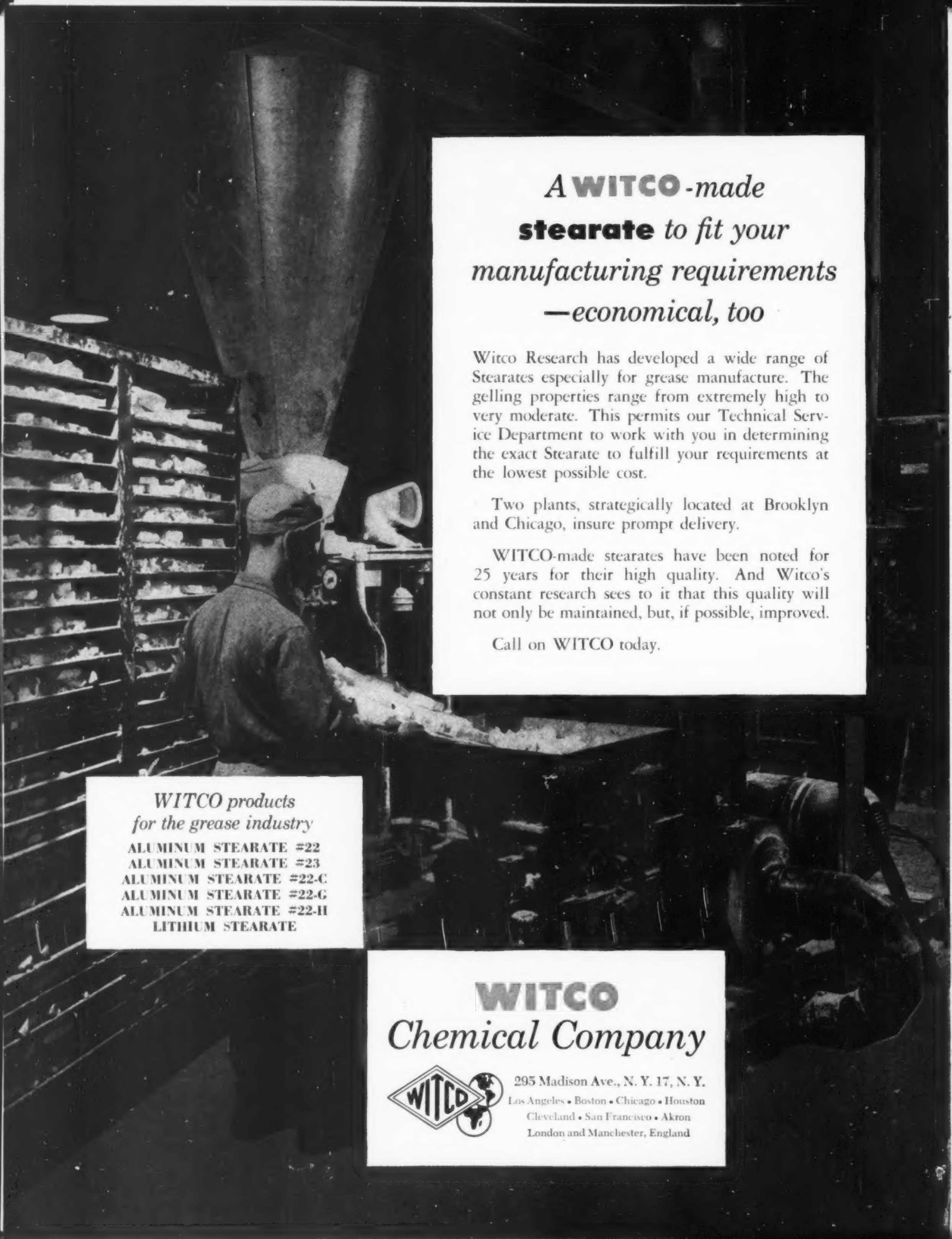
For technical information on the use of Santolene C to solve corrosion problems, write, wire or telephone MONSANTO CHEMICAL COMPANY, Organic Chemicals Division, 1700 South Second Street, St. Louis 4, Mo.

URGENT—If you have empty carboys or returnable drums, please return them to your supplier promptly. They're urgently needed. Containers are scarce!

Santolene: Reg. U. S. Pat. Off.

MONSANTO
CHEMICALS – PLASTICS

Serving Industry . . . Which Serves Mankind


A WITCO-made
stearate to fit your
manufacturing requirements
—economical, too
Witco Research has developed a wide range of Stearates especially for grease manufacture. The gelling properties range from extremely high to very moderate. This permits our Technical Service Department to work with you in determining the exact Stearate to fulfill your requirements at the lowest possible cost.
Two plants, strategically located at Brooklyn and Chicago, insure prompt delivery.
WITCO-made stearates have been noted for 25 years for their high quality. And Witco's constant research sees to it that this quality will not only be maintained, but, if possible, improved.
Call on WITCO today.
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for the grease industry
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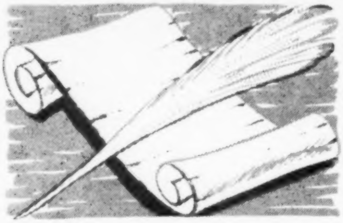

Supporting Your Organization These Suppliers of Your Industry Hold Membership in the N. L. G. I.

SUPPLIERS OF MATERIALS FOR MANUFACTURING LUBRICATING GREASES

Archer-Daniels-Midland Co.
(The Werner G. Smith Co. Div.)
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Cleveland 2, Ohio
Member—F. C. Haas

Armour & Co., Chemical Division
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Chicago 9, Illinois
Member—Dale V. Stingley

American Cyanamid Company
30 Rockefeller Plaza
New York City, New York
Member—A. Scharwachter

Darling & Company
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Chicago 9, Illinois
Member—George W. Trainor

E. I. du Pont de Nemours & Company
Wilmington, Delaware
Member—J. R. Sabina

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Cincinnati 2, Ohio
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Member—H. C. Meyer, Jr.

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New York City 17, New York
Member—Eugene Adams

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41 East 42nd Street
New York City, New York
Member—W. G. McLeod

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Cleveland 6, Ohio
Member—G. G. Unkefer

Leffingwell Chemical Company
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Member—D. E. Murphy

Lubrizol Corporation
Euclid Station
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Brooklyn 22, New York
Member—Ivar Wm. Malmstrom

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Harrison, New Jersey
Member—O. E. Lohrke

Monsanto Chemical Company
1700 Second Street
St. Louis 4, Missouri
Member—J. W. Newcombe

National Lead Company
105 York Street
Brooklyn 1, New York
Member—Alexander Stewart

National Rosin Oil Products, Inc.
R.K.O. Bldg., Rockefeller Center
New York City, New York
Member—Richard Bender

M. W. Parsons—Plymouth, Inc.
59 Beekman Street
New York City 38, New York
Member—H. Bye

Synthetic Products Company
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Member—G. B. Curtiss

Swift & Company Industrial Oil Division
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Hammond, Ind.
Member—F. H. Beneker

Warwick Chemical Company
Division of the Sun Chemical Corporation
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Member—Dr. J. J. Whitfield

Witco Chemical Co.
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Member—B. W. Lewis

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Chicago, Illinois
Member—Henry Frazin

Continental Can Co.
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Kansas City 6, Missouri
Member—T. A. Graham

Geuder, Paeschke & Frey Co.
324 North Fifteenth Street
Milwaukee 3, Wisconsin
Member—Willard J. Flint

Inland Steel Container Company
6532 South Menard Avenue
Chicago 38, Illinois
Member—G. D. Zuck

J & L Steel Barrel Company
405 Lexington Ave.
New York 17, New York
Member—Jerry Lyons

National Steel Container Corporation
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Chicago 38, Illinois
Member—Henry Rudy

Ohio Corrugating Co.
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Warren, Ohio
Member—L. F. McKay

Rheem Manufacturing Company
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Member—G. Wesley Gates

United States Steel Products Co.
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New York City 20, New York
Member—Wm. I. Hanrahan

Vulcan Stamping & Manufacturing Co.
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Member—R. P. Field

Gray Company, Inc.
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The Girdler Corp.
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Morehouse Industries
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Member—J. W. Sylvester

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P. O. Box G
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Freedom Valvoline Oil Co.
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Midwest Research Institute
4049 Pennsylvania
Kansas City 2, Missouri
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Los Angeles 46, California
Member—G. A. Zamboni

Phoenix Chemical Laboratory, Inc.
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Chicago 47, Illinois
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